PRICE DETERMINATION IN THE MARKETS FOR BEEF

by

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ABSTRACT

Beef is the largest single agricultural commodity in the U.S. economy. The economics of beef production, distribution, and consumption have been widely studied, however a key aspect of the beef trade, the problem of price determination, has not been explained adequately to date. A major shortcoming in most prior work is the reliance on the assumption that beef prices are determined at the retail level by what consumers are willing to pay. This study departs from this narrow view by taking a broader look at the entire chain of beef markets—farm, slaughter, and retail. Rather than assuming that prices are made at retail, the model developed here posits that it is the simultaneous interaction of supply and demand in each market which determines prices.

An introductory chapter provides an overview of some of the major conclusions. Next, substantial attention is focussed on the industrial organization of the farm, packing, and retail markets. On the basis of market structure analyses, an econometric model is specified with separate equations for supply and demand at each market level as well as for the farm-carcass and carcass-retail marketing margins.

The results confirm the theory by showing that each of the market supply functions is initially backward bending because of the somewhat unique production characteristics of cattle raising. That is, long-run increases in supply can only be obtained by increasing the size of the breeding herd and thereby withholding animals from short-run production. Further, the results show that long-run supply does respond positively to price at all market levels. The estimates of the long-run price elasticities for the various markets range from 0.2 to 0.6. The demand functions at each market level are found to be of approximately unitary price elasticity. The results also show that marketing margins can be explained in terms of a more rigorous theory. A final chapter applies the econometric model to a problem in law and economics in order to test an oligopsony hypothesis.

Thesis Supervisor: M.A. Adelman
Professor of Economics
Writing this dissertation has been hard work but enjoyable and satisfying. In the process I have learned a good deal and also have incurred some debts which will be difficult to repay fully.

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# Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Structure of the Cattle Raising and Feeding Market</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Structure of the Beef Slaughtering, Processing, and Wholesaling Market</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Product Forms and Extent of the Market</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Seller Concentration</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Market Share Instability</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Product Differentiation</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Economics of Scale</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Capital Requirements</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Regulatory Costs</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>Structure of the Retail Food Market</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Market Concentration</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Product Differentiation</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Barriers to Entry</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Economies of Scale</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Absolute Cost Requirements</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Legal Restraints</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Industry Growth Rates</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Distribution Channels—Vertical Integration</td>
<td>87</td>
</tr>
<tr>
<td>5</td>
<td>An Econometric Model of the Supply and Demand for Cattle and Beef</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Review of Agricultural Econometrics Literature Since 1960</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Introduction and Overview</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Comprehensive Food Models</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>Livestock Models</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Beef and Pork Models</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Study of Price Spreads</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>Critique of Key Findings</td>
<td>115</td>
</tr>
</tbody>
</table>
Table of Contents (Continued)

Specification of Econometric Model--Principles. 118
  Demand for Beef. 121
  Supply of Beef 125
  Equilibration Process. 129
Detailed Specifications for Each Market 131
  Farm-Level Functions 132
    Farm Supply 132
    Farm Demand 138
  Slaughter Level Functions 141
    Slaughter Supply 141
    Slaughter Demand 143
  Retail Level Functions 144
    Retail Supply 144
    Retail Demand 145
Marketing Margin Functions 146
The Full Model 157
Estimation Techniques 157

Chapter 6. Results from Estimation of Econometric Beef Model 174

  Introduction 174
  Estimated Equations for Farm Level 174
    Farm Supply 174
    Farm Demand 180
  Estimated Equations for Slaughter Level 183
    Slaughter Supply 183
    Slaughter Demand 186
  Estimated Equations for Retail Level 188
    Retail Supply 188
    Retail Demand 193
  Estimated Equations for Marketing Margins 193
    Farm-Carcass Margin 193
    Carcass-Retail Margin 195
Summary of Preferred Results 198

Chapter 7. An Application of the Econometric Model:

  The Bray Case 211

  Introduction 211
  Analysis and Hypothesis Specification 215
  A Test of the Oligopsony Hypothesis 223
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.1</td>
<td>Fed Cattle Marketings.</td>
<td>23</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Size of Cattle Feeding Operations, 1962, 1974.</td>
<td>24</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Number and Size of Meatpacking Plants.</td>
<td>31</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Consumption of Beef and Meat, 1950-75.</td>
<td>32</td>
</tr>
<tr>
<td>Table 3.3</td>
<td>Beef Product Shipments By Type for Meats (Plants).</td>
<td>35</td>
</tr>
<tr>
<td>Table 3.4</td>
<td>Number and Size of Sausage and Other Prepared Meat Plants.</td>
<td>37</td>
</tr>
<tr>
<td>Table 3.5</td>
<td>Number, Size, and Type of Meat Wholesalers and Distributors.</td>
<td>38</td>
</tr>
<tr>
<td>Table 3.6</td>
<td>Seller Concentration for Meatpacking Plants.</td>
<td>40</td>
</tr>
<tr>
<td>Table 3.7</td>
<td>Seller Concentration for Sausages and Other Prepared Meats.</td>
<td>43</td>
</tr>
<tr>
<td>Table 3.8</td>
<td>Seller Concentration in Wholesaling for Meat and Meat Products, 1972.</td>
<td>44</td>
</tr>
<tr>
<td>Table 3.9</td>
<td>Leading Meatpacking and Processing Firms.</td>
<td>45</td>
</tr>
<tr>
<td>Table 3.10</td>
<td>Breakdown of Operating Expenses by Company Classification, 1975.</td>
<td>50</td>
</tr>
<tr>
<td>Table 3.11</td>
<td>Value Added by Manufacture and Percent Change in Share by Establishment Size for Meatpacking Plants</td>
<td>52</td>
</tr>
<tr>
<td>Table 3.12</td>
<td>Estimates of Capital Requirements Per Establishment Size for Meatpacking Plants.</td>
<td>55</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Local Market Concentration of Grocery Store and Supermarket Sales by 4, 8, and 20 Largest Firms, 263 SMSA’s, 1954-72</td>
<td>62</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>National Market Share of 20 Leading Grocery Chains, Selected Years, 1954-72</td>
<td>64</td>
</tr>
<tr>
<td>Table 4.3</td>
<td>Survivalship Patterns for Single and Multimunit Retail Grocery Store Firms.</td>
<td>68</td>
</tr>
<tr>
<td>Table 4.4</td>
<td>Survivalship Patterns for Grocery Stores by Annual Sales Size</td>
<td>70</td>
</tr>
<tr>
<td>Table 4.5</td>
<td>Net Profits After Income Taxes as Percent of Stockholder's Equity for Leading Food Chains by Size</td>
<td>73</td>
</tr>
<tr>
<td>Table 4.6</td>
<td>Capital Requirements for Conventional Supermarkets</td>
<td>76</td>
</tr>
<tr>
<td>Table 4.7</td>
<td>Constant (1967) Dollar Sales of Retail Chains, Affiliated Independents, and Unaffiliated Independents, 1947-72</td>
<td>83</td>
</tr>
<tr>
<td>Table 4.8</td>
<td>Number of Chain, Affiliated Independent, and Unaffiliated Independent Stores, 1940-72</td>
<td>84</td>
</tr>
<tr>
<td>Table 4.9</td>
<td>Constant (1967) Dollar Sales Per Store of Unaffiliated Independent Stores, 1947-72</td>
<td>86</td>
</tr>
<tr>
<td>Table 4.10</td>
<td>Number of Wholesale Establishments and Percent Change in Number for Selected Categories of General Line Grocery Wholesalers</td>
<td>90</td>
</tr>
<tr>
<td>Table 4.11</td>
<td>Constant Dollar Sales and Percent Change in Sales for Selected Categories of General Line Grocery Wholesalers</td>
<td>91</td>
</tr>
<tr>
<td>Table 4.12</td>
<td>National Market Share of General Line Grocery Wholesale Sales Among 50 Largest Companies, Selected Years, 1954-72</td>
<td>92</td>
</tr>
<tr>
<td>Table 5.1</td>
<td>Summary of Quantitative Results from Econometric Beef Models</td>
<td>119</td>
</tr>
<tr>
<td>Table 5.2</td>
<td>Specification of Beef Model</td>
<td>158</td>
</tr>
</tbody>
</table>
List of Tables (Continued)

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 6.1</td>
<td>Alternative Regression Results for Farm Supply.</td>
<td>181</td>
</tr>
<tr>
<td>Table 6.2</td>
<td>Alternative Regression Results for Farm Demand.</td>
<td>184</td>
</tr>
<tr>
<td>Table 6.3</td>
<td>Alternative Regression Results for Slaughter Supply.</td>
<td>187</td>
</tr>
<tr>
<td>Table 6.4</td>
<td>Alternative Regression Results for Slaughter Demand.</td>
<td>189</td>
</tr>
<tr>
<td>Table 6.5</td>
<td>Alternative Regression Results for Retail Supply.</td>
<td>192</td>
</tr>
<tr>
<td>Table 6.6</td>
<td>Alternative Regression Results for Farm-Carcass Margin.</td>
<td>196</td>
</tr>
<tr>
<td>Table 6.7</td>
<td>Alternative Regression Results for Carcass-Retail Margin.</td>
<td>199</td>
</tr>
<tr>
<td>Table 6.8</td>
<td>Summary of Elasticity Estimates Obtained from Econometric Beef Model.</td>
<td>201</td>
</tr>
</tbody>
</table>
### List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1</td>
<td>The Markets for Beef</td>
<td>13</td>
</tr>
<tr>
<td>Figure 5.1</td>
<td>Beef Price Spread Determination Under Pure Competition</td>
<td>149</td>
</tr>
<tr>
<td>Figure 5.2</td>
<td>Hypothetical Lag Distributions</td>
<td>165</td>
</tr>
<tr>
<td>Figure 6.1</td>
<td>Plot of Lag Coefficients for Equation (6.1)</td>
<td>177</td>
</tr>
<tr>
<td>Figure 6.2</td>
<td>Plot of Lag Coefficients for Equation (6.13)</td>
<td>185</td>
</tr>
<tr>
<td>Figure 6.3</td>
<td>Plot of Lag Coefficients for Equation (6.22)</td>
<td>191</td>
</tr>
<tr>
<td>Figure 7.1</td>
<td>Factor Price Determination Under Monopsony</td>
<td>217</td>
</tr>
<tr>
<td>Figure 7.2</td>
<td>Beef Price Spread Determination Under Monopsony</td>
<td>220</td>
</tr>
<tr>
<td>Figure 7.3</td>
<td>Plot of Actual and Fitted Values of the Carcass-Retail Margin (MS,R) from a Backcast and Forecast of Equation (7.1)</td>
<td>225</td>
</tr>
</tbody>
</table>

### List of Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix 1.</td>
<td>Retail Seller Concentration and Geographic Compactedness</td>
<td>94</td>
</tr>
<tr>
<td>Appendix 2.</td>
<td>Calculation of the Cost of Inventory for a Newly Opened Grocery Store in 1974</td>
<td>98</td>
</tr>
<tr>
<td>Appendix 3.</td>
<td>Definitions and Sources of Data Used in the Econometric Analysis</td>
<td>208</td>
</tr>
</tbody>
</table>
Chapter 1. Introduction.

A beef animal can be viewed as a machine which produces proteins, calories, and other nutrients that are demanded by final consumers. Per capita consumption of beef has shown a steady long run trend, increasing about 3 per cent per year to the point where in 1975 beef consumption on a carcass weight basis was 120.1 pounds per person. Beef production is the single most important agricultural commodity for American farmers, yielding annually from one-fifth to one-quarter of total cash receipts from farm marketings (not including revenue derived from sale of feed grains). In 1975 cash receipts for cattle and calves totaled $17.5 billion which was 20 percent of total farm income.

The beef price level in recent years has created a large public outcry—farmers continually claim that prices they receive are too low and that middlemen\(^1\) are realizing excess profits while consumers argue that prices they pay are too high. Because beef is one of the nation's key agricultural commodities and because the pricing process seems to be so poorly understood, this study is being undertaken. The approach to the problem is different from a number of other studies in that the industrial organization of the beef trade will be specifically modelled from the farm to the retail level in an attempt to identify the key factors determining prices at each market level.

\(^1\)Disraeli's definition of a middleman: "...he is a man who bamboozles one party and plunders the other."
Since Bain's work, most industrial organization studies have assumed that the performance of an industry in terms of its prices, profitability, and general progressiveness is determined by elements of the market structure of the industry. According to this paradigm, market structure

includes all those considerations which (a firm) takes into account in determining (its) business policies and practices. (Its) market includes all buyers and sellers, of whatever products, whose action (it) considers to influence (its) volume of sales. [3].

The most common aspects of market structure are 1.) degree of seller (and buyer) concentration, 2.) degree of product differentiation, and 3.) the condition of entry, to the market. Concentration is often measured by the market share of the top 4 (8 or 20) firms as a percentage of the total market. Product differentiation is what firms hope to achieve through advertising in that a given product will possess inherently different characteristics in the eyes of the consumer when compared with a similar product. Entry into an industry is usually described in terms of the height of barriers or obstacles which prevent new firms from engaging in the production and sale of a particular product. Three types of barriers are 1.) economies of scale, 2.) absolute cost advantages, and 3.) legal restraints, e.g., patents.

In addition to these elements of market structure, one could identify numerous other factors which could affect industry performance. For example, some structural dimensions which seem particularly relevant to the beef markets are:
- growth rate of market demand,
- channels of distribution,
- locational factors,
- degree of vertical integration,
- type of business—e.g., chain, affiliated independent, or unaffiliated independent supermarkets.

These dimensions are used in the next three chapters to describe the key structural elements of the major beef markets.

Beef is produced, marketed, and consumed roughly according to the schema in Figure 1.1.

Chapter 2 deals with the structure of the cattle raising and feeding market. At this level there are between 1 and 2 million farms and ranches on which beef is produced. In 1976 there were 127 million head of cattle on these farms and ranches with a farm value of $190 per head.\[4\] The principal areas in which beef is produced are the Western and Southern sections of the U.S. The last twenty-five years have seen a great rise in the importance of grain feedlots. Although some cattle may go directly from grass feeding on the farm to the slaughter-house, a growing majority, somewhere between 65 and 80 percent, typically are sent to feedlots for further fattening. The decision to grass feed an animal or place it in a feedlot depends on price expectations for fed cattle and the relative cost of feedlot operations. Farmers and feeders alike must determine what percentage of the stock of all cattle are to be slaughtered each period. Given age, sex, cost of inputs, and
Figure 1.1 The Markets for Beef.
expected selling prices a beef animal can be slaughtered as a vealer, a fat calf, or it can be fed and/or grazed until the age of 2 or 3 whereupon it may weigh 1100-1400 pounds before slaughtering.

Although simplified, the following structural traits seem to apply to cattle farming and feeding:

- there are numerous sellers none of which has control over price,
- products are homogeneous with no effective advertising, and
- entry conditions are not difficult with fairly low capital requirements.

In short, conditions at the farm level are close to the norm of pure competition.

Chapter 3 deals with the intermediate market level which slaughters and processes live cattle, and distributes the product to the final marketers. Seller concentration was once high in the meatpacking industry, but has markedly declined from 41 per cent in 1947 to 22 per cent in 1972. There are a number of reasons for this drastic reduction in concentration. First, the development after World War II of an integrated truck and highway system coupled with the fact that about one third of the animal's live weight is dropped during slaughtering meant that substantial cost savings could be realized through decentralization. Thus, new packing plants were more likely to locate near their sources of supply. Another significant development has been that many new plants tend to specialize in the slaughter of a particular species. Also studies have found that the minimum efficient size of plant is
relatively small in comparison to the size of the market. These factors in conjunction with the rapid growth of beef production made it increasingly easy for new firms to enter the industry and erode the share of market leaders.

Chapter 4 treats the final market level at retail which is primarily composed of the grocery or supermarket industry. The market in which food is traded at retail encompasses a fairly small geographic area defined by consumer shopping habits and transportation systems. The U.S. Bureau of Census takes the Standard Metropolitan Statistical Area (SMSA) as an approximation for the local retail grocery market. Seller concentration has been increasing, mainly due to mergers, to the point where in 1972 the simple average four-firm concentration ratio across 263 SMSA's was 52.4 percent up from 45.5 percent in 1954. Although by most industrial standards this would be a moderately concentrated market, most economists feel that these markets are workably competitive.

Entry into the grocery industry is not difficult. Single store firms are clearly subject to diseconomies of small scale, but as few as 2 to 10 stores seem to be the minimum efficient scale. At the plant or store level, $1 million in annual sales is the minimum efficient size. In many large metropolitan markets this type of firm and plant size would be a small fraction of the total sales in the market, so scale economies in retailing are probably not a large deterrent to entry. Also, capital investment is fairly modest compared to most industries; a 6 to 10 store firm including the
cost of inventory would require an initial investment of from $5 to 9 million.

Grocery store sales were $153 billion in 1976. Of this total, retail chains, i.e., firms with 11 or more stores, had 47% and independents or non-chains sold 49%. The largest four chains (recently they have been Safeway, A&P, Kroger, and American) have a fairly small share of the national market—about 18 to 22 percent since World War II. The troubles of A&P have been widely publicized and they account for part of the loss in market share of the leading firms. For the industry as a whole, market growth is fairly steady, growing with consumer income, and typically strong enough to accommodate different types and sizes of stores and firms. Vertical integration into wholesaling, either through affiliation with a wholesaler or operation of one's own warehouse, is becoming increasingly important. From all appearances the industry seems to be structurally competitive.

Based upon the discussion of the structure of these three markets, an econometric model is developed in Chapter 5. Following a review and critique of the existing literature on beef and livestock models, a new direction is taken in the specification by allowing for simultaneous price and quantity determination in each market. Past analyses have too often singled out retail demand as the controlling force in price determination. Microeconomic theory is applied to each market in order to derive separate equations for supply and demand at the farm, slaughter, and retail levels. Also, because
of the inherent interest in the size of price spreads, two additional reduced form equations are developed for the farm-carcass and carcass-retail marketing margins.

The results, reported in Chapter 6, generally support the approach taken to modelling the price determination process. A more realistic description of the dynamic properties of supply response is gained by use of the Almon or polynomial distributed lag procedure. This econometric technique has never before been applied to beef supply modelling in a simultaneous equation system. The specific econometric results show that supply is initially backward bending in each market because of the particular production characteristics of cattle raising. In the long run all of the supply functions are positively sloped with price elasticities ranging from approximately 0.2 to 0.6. Slaughter and retail supply functions appear to be more price elastic than the farm function because these producers are not saddled with the large fixed costs borne by farmers. On the demand side each function is found to have an own-price elasticity of approximately 1.0. These results imply an elasticity of substitution between farm inputs and processing-distributing factors of well over 1.0 which is in direct opposition to the standard assumption in the literature that inputs are combined in fixed proportions. The results for the marketing margins show them to be reduced form equations of the six structural equations. Margins are primarily explained by costs.

In Chapter 7 an application of the econometric model to a problem in law and economics is discussed. The Bray case was a
private antitrust action brought in 1968 by some cattlemen against the country's largest retail grocery chains [2]. The issues in the case are cast in a simple microeconomic framework suitable for testing the hypothesis that there was an oligopsonistic conspiracy operative in the wholesale carcass market during the period 1956-71. The results of an econometric test of this hypothesis are briefly discussed.
References


Agriculture in general probably comes closest to the economists's ideal of pure competition. There are numerous sellers none of which has control over price. Entry is easy for almost anyone. Product differentiation is virtually nonexistent. As one would expect rates of return to agricultural producers have consistently been low in comparison to less competitively structured industries.

Cattle raising and feeding are not atypical agricultural markets in terms of their structural characteristics. In 1976 there were 128 million head of cattle on the nation's 1-2 million farms and ranches with an aggregate value of $24 billion or $190. per head (7). Of the total number of cattle about 47 percent were beef cows, 12 percent milk cows, 20 percent heifers, 18 percent steers, and 3 percent bulls. Close to 40 percent of the total number come from just six

---

1 The other major asset is real estate devoted to agriculture which in 1976 was valued at $422 billion; not all of this land is used to raise livestock(5).

2 The following definitions may be helpful: A calf can be a male or female animal between zero and nine months old. A heifer is a female, between ten and twenty-eight months old, which has not yet produced a calf. A cow is a female, between twenty-eight and eighty-four months old, which can potentially bear one calf per year. A steer is a castrated male, between nineteen and thirty months old. A bull is an uncastrated male, of up to eighty-four months of age.
states—Iowa, Kansas, Missouri, Nebraska, Oklahoma, and Texas. Yet, the average size of a beef cow herd is only some 42 head. [1].

The capital requirements involved in cattle farming are minimal from the perspective of most industrial activity but probably substantial for an individual. The minimum efficient size of herd is approximately 300 head of cows [2]. Land is required for the cattle to forage and acreage requirements average about 16 acres per animal [1]. (About 8.9 million acres were devoted to pasture land in 1969.) In 1972, total investment requirements for a moderately sized grain-livestock farm were about $.5 million with additional finishing operations requiring another $250,000 outlay [3].

When born, a calf will weigh about 75 pounds and will nurse on its mother for about 5 months. Then it will graze on range grasses, pasture, hay and supplements for another 7 months, gaining about 1.5 pounds per day. At that point the farmer may decide, depending on market conditions, i.e., prices of cattle and feed grains, to sell the animal, which now weighs 400-500 pounds, to a commercial feedlot or the animal may be kept on grass and possibly fed at a later point.

Since World War II the major structural change in the farm sector of the beef industry has been the emergence of the large cattle feedlot. The number of cattle marketed through feedlots increased from
10.8 million head in 1955 (or 41 percent of total slaughter) to 28.2 million head in 1972 (representing 78 percent of total beef production). See Table 2.1. After 1972 the percentage fed declined because feed costs soared in relation to fed cattle prices and the alternative of grass feeding.

The process of feeding involves scientific methods of combining the various inputs to the animals' diet so as to produce marbled meat of high quality. Typically the fattening animal will gain 2.5-3.0 pounds per day in the feedlot and will be sold for slaughter at about 1,050-1,100 pounds. The feedlot has only a short time to make selling decisions once the animal has reached its optimal weight, because feed conversion efficiencies drop off sharply above 1,100 pounds (2).

As the growth of the feedlot industry increased in the postwar period, the average size of a cattle feedlot expanded as well. In 1962 there were over 200,000 cattle feedlots, but by 1974 they had shrunk in number considerably. See Table 2.2. Clearly the small feedlots of under 1,000 head one-time capacity are fading in importance while the larger feedlots of over 8,000 head capacity are gaining. Table 2 shows that concentration is such that 1.4 percent of the feedlots in 1974, i.e., those with capacity larger than 1,000 head, accounted for 65 percent of the feed cattle marketed. Even so, the largest feedlot probably accounts for no more than 1 or 2 percent of total cattle supply; while the entire group of the largest lots, those with capacity greater than 32,000 head, only marketed about 12.5 percent of the total slaughter in 1974.
Table 2.1. Fed cattle marketings.

<table>
<thead>
<tr>
<th>Year</th>
<th>Million head</th>
<th>Percent of total slaughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>10.8</td>
<td>41</td>
</tr>
<tr>
<td>1960</td>
<td>13.5</td>
<td>52</td>
</tr>
<tr>
<td>1965</td>
<td>18.9</td>
<td>57</td>
</tr>
<tr>
<td>1970</td>
<td>25.9</td>
<td>73</td>
</tr>
<tr>
<td>1971</td>
<td>25.3</td>
<td>74</td>
</tr>
<tr>
<td>1972</td>
<td>28.2</td>
<td>78</td>
</tr>
<tr>
<td>1973</td>
<td>26.3</td>
<td>77</td>
</tr>
<tr>
<td>1974</td>
<td>24.4</td>
<td>66</td>
</tr>
<tr>
<td>1975</td>
<td>21.3</td>
<td>51</td>
</tr>
</tbody>
</table>

* Estimate for total U.S.

Table 2.2. Size of cattle feeding operations, 1962 and 1974.¹

<table>
<thead>
<tr>
<th>Capacity of feedlots (head)</th>
<th>1962</th>
<th>1974</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of lots (#)</td>
<td>Cattle marketed as percent of total (%)</td>
</tr>
<tr>
<td>Under 1,000</td>
<td>234,646</td>
<td>63</td>
</tr>
<tr>
<td>1,000-7,999</td>
<td>1,380</td>
<td>19</td>
</tr>
<tr>
<td>8,000-31,999</td>
<td>132</td>
<td>16</td>
</tr>
<tr>
<td>32,000 &amp; over</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>236,163</td>
<td>100</td>
</tr>
</tbody>
</table>

¹1962 data are for 32 states, and 1974 for 23 states.

Some economies of scale have been found to exist in cattle feeding, but the evidence is mixed and any advantages of size seem to disappear well below the largest sized lots (4). Capital requirements in feeding are larger than for farming but are still small on a relative basis. To build and equip a 30,000 head capacity lot cost about $50 per head or $1.5 million in 1972 (2). Annual operating expenses for a feedlot can be much more significant, however. To purchase and feed a 600 pound steer so that it reaches 1,050 pounds in 5 to 6 months cost about $375 in 1972 in the Texas Panhandle (2). This means that annual operating expenses for a 30,000 head feedlot ranged from $17 to $22 million in 1972. Yet, this does not mean there are any significant barriers to entering cattle feeding because the minimum efficient size of a lot may be as small as one-sixth the size of the 30,000 head feedlot (2).
References


Introduction.

A number of significant changes have occurred in the organization of the meatpacking industry in the twentieth century. What was once a tightly structured industry dominated by a few centrally located, relatively large firms has been transformed to a much more geographically dispersed industry, composed of numerous small, medium, and large firms. The primary functions of meat packers, processors, and distributors are—slaughtering live animals, processing meat, and selling/distributing meat at wholesale. Many firms engage in all of these activities simultaneously while others specialize in only one function. Those firms or plants primarily doing slaughtering have traditionally been called meat packers. This term refers to the period before modern refrigeration methods when livestock were killed largely during the winter and the product "packed" in salt or brine to preserve it for consumption during the warmer months (31, p. 65). On a sales basis meatpacking plants account for the largest share of the industry.

Meat processors deal in essentially the same product as packers except that the former group does no slaughtering. Thus, processors are those firms which buy carcasses, perform primarily a fabricating function, including breaking and boning, and then sell wholesale (primal)
or retail cuts, sausages, or other prepared meats.

Wholesalers are a disparate, facilitative group which does no slaughtering and little, if any, processing. There are three main types: 1) merchant wholesalers take title to the meat products, do some fabricating as breakers or boners, and act as suppliers to retail sellers; 2) manufacturers' branch houses are separate establishments which perform the distribution function for parent slaughterers and processors; 3) merchandise agents and brokers do not take title to or physical possession of the product but represent clients in buying and selling.

Over the period 1890-1920, the meatpacking industry, in part due to the development of the insulated refrigerator railway car, became increasingly concentrated in the hands of a few, large multi-species slaughtering firms. In 1916, the five largest firms, i.e., Swift, Armour, Morris (acquired by Armour in 1923), Wilson, and Cudahy, slaughtered 82.2 percent of the interstate cattle shipments, 76.6 percent of the calves, 86.4 percent of the sheep, and 61.2 percent of the hogs (2, p. 20). Terminal stockyards and distribution facilities serving the large eastern markets also were virtually totally controlled by these five firms

---

1 Carcasses are typically broken or cut into seven primal or wholesale cuts—chuck, rib, loin, round, plate, brisket, and flank. From that point, they may be cut into over twenty retail cuts, e.g., porterhouse and t-bone steaks, chuck roast, or ground beef.

2 The history of the early period is analyzed in Kujovich (13), Arnould (2), and McCoy (16, pp. 156-57).
who owned 89 percent of the branch houses and 90 percent of the car-routes [2, p. 20]. The government became concerned about such high levels of seller concentration since meatpacking at that time was one of the nation's largest industries. This concern resulted in the Packers' Consent Decree of 1920, which prohibited a number of uncompetitive practices by which the firms had attempted to control the market for dressed beef.

The provisions of the decree included:

1) that Swift, Armour, Morris, Wilson, and Cudahy stop any combination in restraint of trade, unfair competition, or other unlawful practices;

2) that they divest their financial interests in the public stockyards where the livestock were assembled for sale to packers; that they also divest any holdings of terminal railroads adjacent to the yards, or of market newspapers and journals which carried information on prices and farmers' receipts;

3) that they not engage in meat or grocery retailing or in maintaining public cold storage facilities; and

4) that they submit to periodic review by the U.S. District Court.

In the following year, Congress enacted the Packers and Stockyards Act of 1921 which created a regulatory agency to ensure that the meat marketing system remained free of these abuses.
Product Forms and Extent of the Market.

The number of meatpacking establishments (plants) has been on the rise for most of this century. Table 2 shows that an all-time high (for Census years) of 2,992 establishments was reached in 1963. Since then, the number of establishments has trended downward somewhat. The number of companies engaged in meatpacking also peaked in 1963 at 2,833 [25]. A good part of this reduction in numbers since 1963 can be attributed to the enactment of the Wholesome Meat Act of 1967 which imposed minimum health and inspection standards on packing plants in all states. In some areas small plants chose to shut down rather than make the investments required to comply with the federal regulations [6].

There are several types of data available as well as methods for measuring the growth of the meatpacking industry over time. First, the most simple and direct approach is to evaluate the change in physical quantities over time. Table 3.2 shows beef and meat consumption in millions of pounds (carcass weight) in the post-World War II era. Aggregate beef consumption has grown rapidly during this period, increasing at about 4% per year. This is a faster rate of growth than for the other meat categories, i.e., veal, lamb and mutton, and pork, so beef's share of total meat consumption rose from a low of 40.6% in 1951 to a high of 66.3% in 1975. Per capita beef consumption has also grown at a fairly rapid pace; almost doubling since 1950.

Although most firms operate only one plant, some of the largest firms do have several establishments, but usually less than 10-12 plants. The average establishment to company ratio is 1.06.
<table>
<thead>
<tr>
<th>Year</th>
<th>Establishments</th>
<th>Value of Shipments</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(number)</td>
<td>(mil $)</td>
<td>(thous $)</td>
</tr>
<tr>
<td>1889</td>
<td>1,118</td>
<td>562</td>
<td>503</td>
</tr>
<tr>
<td>1899</td>
<td>882</td>
<td>784</td>
<td>889</td>
</tr>
<tr>
<td>1919</td>
<td>1,304</td>
<td>4,246</td>
<td>3,256</td>
</tr>
<tr>
<td>1929</td>
<td>1,277</td>
<td>3,435</td>
<td>2,690</td>
</tr>
<tr>
<td>1939</td>
<td>1,392</td>
<td>2,540</td>
<td>1,825</td>
</tr>
<tr>
<td>1947</td>
<td>2,154</td>
<td>8,970</td>
<td>4,164</td>
</tr>
<tr>
<td>1954</td>
<td>2,367</td>
<td>10,265</td>
<td>4,337</td>
</tr>
<tr>
<td>1958</td>
<td>2,810</td>
<td>11,972</td>
<td>4,260</td>
</tr>
<tr>
<td>1963</td>
<td>2,992</td>
<td>12,436</td>
<td>4,156</td>
</tr>
<tr>
<td>1967</td>
<td>2,697</td>
<td>15,576</td>
<td>5,775</td>
</tr>
<tr>
<td>1972</td>
<td>2,475</td>
<td>23,024</td>
<td>9,303</td>
</tr>
</tbody>
</table>

NA - not available

1 Deflated by BLS, Wholesale Price Index for Processed Foods and Feeds, (1967=1.000).

### Table 3.2. Consumption of beef and meat, 1950-75.

<table>
<thead>
<tr>
<th>Year</th>
<th>Beef Consumption</th>
<th>All Meats Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Mil. lb.)</td>
<td>(Lb.)</td>
</tr>
<tr>
<td></td>
<td>Percent change</td>
<td>Per Person</td>
</tr>
<tr>
<td>1950</td>
<td>9,529</td>
<td>63.4</td>
</tr>
<tr>
<td>1951</td>
<td>8,472</td>
<td>-11.1</td>
</tr>
<tr>
<td>1952</td>
<td>9,548</td>
<td>12.7</td>
</tr>
<tr>
<td>1953</td>
<td>12,113</td>
<td>26.9</td>
</tr>
<tr>
<td>1954</td>
<td>12,743</td>
<td>5.2</td>
</tr>
<tr>
<td>1955</td>
<td>13,313</td>
<td>4.5</td>
</tr>
<tr>
<td>1956</td>
<td>14,121</td>
<td>6.1</td>
</tr>
<tr>
<td>1957</td>
<td>14,242</td>
<td>0.9</td>
</tr>
<tr>
<td>1958</td>
<td>13,786</td>
<td>-3.2</td>
</tr>
<tr>
<td>1959</td>
<td>14,202</td>
<td>3.0</td>
</tr>
<tr>
<td>1960</td>
<td>15,147</td>
<td>6.7</td>
</tr>
<tr>
<td>1961</td>
<td>15,902</td>
<td>5.0</td>
</tr>
<tr>
<td>1962</td>
<td>16,326</td>
<td>2.7</td>
</tr>
<tr>
<td>1963</td>
<td>17,612</td>
<td>7.9</td>
</tr>
<tr>
<td>1964</td>
<td>18,899</td>
<td>7.3</td>
</tr>
<tr>
<td>1965</td>
<td>19,060</td>
<td>0.9</td>
</tr>
<tr>
<td>1966</td>
<td>20,140</td>
<td>5.7</td>
</tr>
<tr>
<td>1967</td>
<td>20,793</td>
<td>3.2</td>
</tr>
<tr>
<td>1968</td>
<td>21,627</td>
<td>4.0</td>
</tr>
<tr>
<td>1969</td>
<td>22,065</td>
<td>2.0</td>
</tr>
<tr>
<td>1970</td>
<td>22,926</td>
<td>3.9</td>
</tr>
<tr>
<td>1971</td>
<td>23,084</td>
<td>0.7</td>
</tr>
<tr>
<td>1972</td>
<td>23,962</td>
<td>3.8</td>
</tr>
<tr>
<td>1973</td>
<td>22,812</td>
<td>-4.8</td>
</tr>
<tr>
<td>1974</td>
<td>24,489</td>
<td>7.4</td>
</tr>
<tr>
<td>1975</td>
<td>25,398</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Source: USDA, *Livestock and Meat Statistics*, Table 123, p.206
A second method for analyzing industry growth is to look at the change in industry value of shipments, either in aggregate or per plant form, as in Table 3.1. In order to control for price level changes, the value of shipments (and value added) data are divided by the wholesale price index to obtain a deflated or constant 1967 dollar figure. Table 3.1 shows that for this century the deflated value of shipments for meatpackers has steadily increased between Census years except for the period of the Great Depression. (This corresponds with the quantity data in Table 3.2, which exhibit a similar trend; note that the only year-to-year decreases occur in the recessionary periods of 1951, 1958, and 1973.)

Growth in the average size of plant, shown in Table 3.1, has been somewhat erratic. There were fairly large plants in 1929 when the industry was still highly concentrated. Then the deflated value of shipments per plant declined for a long period until in 1967 the size of plant was approximately the same as in 1929.1 In 1972, the mean plant size jumped significantly, again, this is in part due to the effects of the Wholesome Meat Act.

One final means of evaluating industry growth is the analysis of value added, which is obtained by subtracting the total cost of materials from the value of shipments and adjusting for inventory changes.

1Note, however, that the "extent of the market" was about twice as large in 1967, so entry barriers were that much lower in the later period.
Constant dollar value added in Table 3.1 also exhibits a steady long-run increase. The reason that value added in meatpacking is much less than the value of shipments is that the cost of raw materials is an extremely large proportion of each sales dollar.¹

As for the form of product shipped by meatpackers, about 70 percent of all beef shipments were in the form of whole carcasses in 1972 (see Table 3.3). However, primal and fabricated cuts are growing in importance, as they accounted for one-fifth of industry shipments as of 1972. The percentage jump in the most recent period was exceedingly large.² Other categories are fairly small and unimportant.

It should be noted that packer shipment of primal cuts in boxes, the so-called boxed beef program, is a major innovation in the industry that has taken place since 1960. Retailers that operate their own meat warehouses also are involved in boxing operations. The growth in boxed beef is the result of several economic factors including: savings in transportation costs and the matching of certain types of cuts with the demands of retail consumers in local areas.

¹The American Meat Institute reports that the cost of livestock and other raw materials as a percent of total sales in the meatpacking industry ranged between 71.1 and 31.3 percent over the period 1947-75. (1)

²There is good reason to think that fabricating, including boxing, has grown even more since the last Census. For example, Engelman notes that boxed beef production by packers increased from 11.7 percent of fed beef in 1971 to 33.3 percent in 1975 (7, p. 271). Also a recent trade press article reports that, "although it is difficult to validate, it is estimated about 75 percent of the beef moved through supermarkets is boxed, broken into sub-primals by the packer, or at the chain warehouse (15, p. 1).
Table 3.3. Beef product shipments by type for meatpacking plants (SIC 2011).

<table>
<thead>
<tr>
<th>Type of Product</th>
<th>1963</th>
<th>1967</th>
<th>1972</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value (mil $)</td>
<td>Percent (%)</td>
<td>Value (mil $)</td>
</tr>
<tr>
<td>Whole carcass beef</td>
<td>4,098</td>
<td>71.8</td>
<td>5,380</td>
</tr>
<tr>
<td>Primal and fabricated cuts</td>
<td>910</td>
<td>15.9</td>
<td>1,080</td>
</tr>
<tr>
<td>Boneless beef, incl. hamburger</td>
<td>378</td>
<td>6.6</td>
<td>526</td>
</tr>
<tr>
<td>Variety meats (edible organs)</td>
<td>121</td>
<td>2.1</td>
<td>170</td>
</tr>
<tr>
<td>Other edible beef incl. corned beef</td>
<td>47</td>
<td>0.8</td>
<td>44</td>
</tr>
<tr>
<td>Other, n.s.k.</td>
<td>153</td>
<td>2.7</td>
<td>199</td>
</tr>
<tr>
<td>Total beef, not canned or sausage</td>
<td>5,708</td>
<td>100.0</td>
<td>7,398</td>
</tr>
<tr>
<td>Total product shipments, incl.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>beef, veal, lamb, pork</td>
<td>9,260</td>
<td>61.6</td>
<td>11,830</td>
</tr>
</tbody>
</table>

1Percent column shows total beef shipments as a percentage of total meat product shipments.

A slightly different picture of number and sizes emerges from looking at data for meat processors in Table 3.4. The number of plants has been relatively constant since 1939, but the deflated value of shipments and value added on both an aggregate and per plant basis have risen rapidly.

Significant changes have also occurred in the wholesale distribution sector of the industry. Early in this century, the market power of national packers derived in part from "packing house branches" or "branch houses" (29, pp. 44-45). These units served as geographical extensions of the parent packing plants processing and wholesaling departments. As Table 3.5 shows, however, today the role of the branch house is greatly diminished.

The number of packer branch houses has trended downward throughout the post-World War II era, dropping 25 percent in just the five years, 1967-72. In contrast, merchant wholesalers outnumber branch house by about 10 to 1, and outsell them by approximately 3 to 1. Branch houses are comparatively large in terms of average sales per establishment and continue to grow as the smaller units are shut down.

Another important structural development in the post-War era was the start up by chains of meat warehouses capable of handling straight carlot shipments. This also had the effect of reducing the role of the branch houses because retailers realized scale economies in distribution.

1Recall that meat processors are non-slaughterers and not necessarily a separate business entity from packers, but simply a separate establishment under Bureau of Census definitions.
Table 3.4.  Number and size of sausage and other prepared meat plants (SIC 2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>Plants (number)</th>
<th>Value of Shipments</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Per Plant (mil $)</td>
<td>Deflated$^1$ Per Plant (mil $)</td>
<td>Actual Per Plant (thous $)</td>
</tr>
<tr>
<td>1939</td>
<td>1,197</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1947</td>
<td>1,264</td>
<td>1,601</td>
<td>1,267</td>
</tr>
<tr>
<td>1954</td>
<td>1,316</td>
<td>1,551</td>
<td>1,178</td>
</tr>
<tr>
<td>1958</td>
<td>1,494</td>
<td>2,066</td>
<td>1,383</td>
</tr>
<tr>
<td>1963</td>
<td>1,341</td>
<td>2,130</td>
<td>1,588</td>
</tr>
<tr>
<td>1967</td>
<td>1,374</td>
<td>3,008</td>
<td>2,189</td>
</tr>
<tr>
<td>1972</td>
<td>1,311</td>
<td>4,632</td>
<td>3,533</td>
</tr>
</tbody>
</table>

NA - not available

$^1$Deflated by, BLS, Wholesale Price Index for Processed Foods and Feeds, (1967=1.000).

Table 3.5. Number, size, and type of meat wholesalers and distributors (SIC 5147).

<table>
<thead>
<tr>
<th>Item and Type</th>
<th>1963</th>
<th>1967</th>
<th>1972</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Deflated</td>
<td>Actual</td>
</tr>
<tr>
<td>Establishments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Merchant wholesalers</td>
<td>5,170</td>
<td>---</td>
<td>5,041</td>
</tr>
<tr>
<td>Mfcr's sales branches</td>
<td>577</td>
<td>---</td>
<td>616</td>
</tr>
<tr>
<td>Mdse. agents, brokers</td>
<td>134</td>
<td>---</td>
<td>163</td>
</tr>
<tr>
<td>Merchant wholesalers</td>
<td>5,371</td>
<td>5,806</td>
<td>7,395</td>
</tr>
<tr>
<td>Mfcr's sales branches</td>
<td>2,446</td>
<td>2,644</td>
<td>2,811</td>
</tr>
<tr>
<td>Mdse. agents, brokers</td>
<td>810</td>
<td>876</td>
<td>853</td>
</tr>
<tr>
<td>Sales per establishment</td>
<td>(thous $)</td>
<td>(thous 1967 $)</td>
<td>(thous $)</td>
</tr>
<tr>
<td>Merchant wholesalers</td>
<td>1,039</td>
<td>1,123</td>
<td>1,467</td>
</tr>
<tr>
<td>Mfcr's sales branches</td>
<td>4,239</td>
<td>4,583</td>
<td>4,563</td>
</tr>
<tr>
<td>Mdse. agents, brokers</td>
<td>6,045</td>
<td>6,535</td>
<td>5,233</td>
</tr>
</tbody>
</table>

1 Sales amounts were deflated by the BLS, Wholesale Price Index for Processed Foods and Feeds, (1967=1.000).

Source: U.S. Dept. of Commerce, Bureau of Census, Census of Wholesale Trade, selected years.
Seller Concentration.

One of the most striking aspects of the modern meatpacking industry is its extremely large decrease in the four-firm seller concentration ratio (CR4). Table 3.6 shows that concentration dropped from 41 percent to 22 percent over the period, 1947-72. This decline in concentration is remarkable in two respects. First, only a handful of 4-digit industries have ever exhibited a halving of the CR4 over such a span; none of the industries is as large. Second, this was more of a levelling phenomenon, i.e., where the largest firms grew more slowly than the smaller firms, rather than a matter of all firms getting smaller as in a declining industry. This is evidenced by increases in concentration in all other size categories:

- the 5th-8th largest group goes from a 13 to 15 percent share from 1947-72,
- the 9th-20th largest group goes from a 9 to 14 percent share from 1947-72, and
- the 21st-50th largest group goes from an 8 to 15 percent share from 1958-72.
Table 3.5. Seller concentration for meat packing plants (SIC 2011)

Percentage of value added accounted for in--

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th largest</td>
<td>41</td>
<td>39</td>
<td>34</td>
<td>31</td>
<td>27</td>
<td>26</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>5th-8th</td>
<td>13</td>
<td>12</td>
<td>8</td>
<td>11</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>1st-8th</td>
<td>54</td>
<td>51</td>
<td>46</td>
<td>42</td>
<td>39</td>
<td>38</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>9th-20th</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>12</td>
<td>NA</td>
<td>12</td>
<td>NA</td>
<td>14</td>
</tr>
<tr>
<td>1st-20th</td>
<td>63</td>
<td>60</td>
<td>57</td>
<td>54</td>
<td>NA</td>
<td>12</td>
<td>NA</td>
<td>15</td>
</tr>
<tr>
<td>21st-50th</td>
<td>NA</td>
<td>NA</td>
<td>8</td>
<td>10</td>
<td>NA</td>
<td>12</td>
<td>NA</td>
<td>15</td>
</tr>
<tr>
<td>1st-50th</td>
<td>NA</td>
<td>NA</td>
<td>65</td>
<td>64</td>
<td>NA</td>
<td>62</td>
<td>NA</td>
<td>66</td>
</tr>
</tbody>
</table>

NA - not available

In short, many firms have grown large in response to large increases in demand. The industry is no longer characterized by the dominance of a few giant firms as in the early part of this century. Rather there are now many firms of roughly equal size, none of which controls a large segment of the market.

There are a number of reasons for the sharp drop-off in CR4 and concurrent entry by new firms which were able to thrive. First, the development of an interstate highway system (and probably ICC regulations) made trucking an economically attractive mode of transportation compared with the railroads. A steer loses well over a third of its live weight during slaughtering. Thus a transportation cost differential coupled with technical breakthroughs in refrigeration methods meant that packing plants which located nearer cattle production areas could realize significant savings by not shipping live animals to central slaughter houses. Also, wage costs were often lower in the hinterlands [18, pp. 17-22]. The NCFM further claims that Federal grading of beef made it easier for entering firms to compete with their more established rivals, because there was little effective product differentiation. Finally, the large reduction in concentration provides strong indication that economies of scale are achieved at a fairly small level of output. These last two issues are examined in more detail below.

The other sectors of the industry also exhibit a remarkably
low level of concentration. Concentration in meat processing has been and remains at a very minimal level (see Table 3.7). The CR4 in 1972 was 19 percent and the largest fifty firms accounted for just over half of all industry shipments. Relative to most manufacturing industry, this is a very low level of concentration. Concentration in meat wholesaling and distributing is also at an extremely low level. Table 3.8 shows that in 1972 the average CR4 of the 3 groups, i.e., meat wholesalers, branch houses, and agents-brokers, was 15.9 percent.

**Market Share Instability and Emergence of the New Breed**

As noted above, meatpacking is a high sales volume but low value added industry; through it approximately $31.7 billion in revenues will pass in 1977 [26, p. 249]. While meatpackers have been among the nation's largest manufacturing firms over the years, the composition of the leading firms has changed considerably in the post-World War II era. Many of the old-line packers have been dropped from their perch by a fast-growing, new breed of packing firm which has been able to take advantage of:

1) relatively small economies of scale and the related efficiencies of specializing in single-species plants,

2) certain locational factors favoring decentralization.

For their part the old-line packers have had difficulty adjusting to these changing conditions as they were often locked into very large, multiple-species plants that were poorly situated.

Although inter-firm sales comparisons are difficult to make, Table 3.9 is an attempt to demonstrate the changing fortunes in the packing/processing trade. In 1929, and well back to the beginning of the century,
Table 3.7. Seller concentration for sausages and other prepared meats (SIC 2013)

Percentage of value added accounted for in--

<table>
<thead>
<tr>
<th></th>
<th>1963 (%)</th>
<th>1966 (%)</th>
<th>1967 (%)</th>
<th>1970 (%)</th>
<th>1972 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lst-4th largest</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>5th-8th</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>NA</td>
<td>7</td>
</tr>
<tr>
<td>lst-8th</td>
<td>23</td>
<td>23</td>
<td>22</td>
<td>NA</td>
<td>26</td>
</tr>
<tr>
<td>9th-20th</td>
<td>12</td>
<td>NA</td>
<td>12</td>
<td>NA</td>
<td>12</td>
</tr>
<tr>
<td>lst-20th</td>
<td>35</td>
<td>NA</td>
<td>34</td>
<td>NA</td>
<td>38</td>
</tr>
<tr>
<td>21st-50th</td>
<td>16</td>
<td>NA</td>
<td>17</td>
<td>NA</td>
<td>16</td>
</tr>
<tr>
<td>lst-50th</td>
<td>51</td>
<td>NA</td>
<td>51</td>
<td>NA</td>
<td>54</td>
</tr>
</tbody>
</table>

NA - not available

Table 3.8. **Seller concentration in wholesaling for meat and meat products (SIC 5147), 1972.**

Number of establishments and percent of sales accounted for by top firms

<table>
<thead>
<tr>
<th>Firms</th>
<th>Number of establishments (no.)</th>
<th>Percent of sales (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th largest</td>
<td>327</td>
<td>15.9</td>
</tr>
<tr>
<td>5th-8th</td>
<td>58</td>
<td>5.3</td>
</tr>
<tr>
<td>1st-8th</td>
<td>385</td>
<td>21.2</td>
</tr>
<tr>
<td>9th-20th</td>
<td>39</td>
<td>6.5</td>
</tr>
<tr>
<td>1st-20th</td>
<td>424</td>
<td>27.7</td>
</tr>
<tr>
<td>21st-50th</td>
<td>46</td>
<td>8.7</td>
</tr>
<tr>
<td>1st-50th</td>
<td>470</td>
<td>36.4</td>
</tr>
<tr>
<td>Total</td>
<td>5,556</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Total Sales (mill.$) 18,333
Total Firms (no.) 4,991

Table 3.9  Leading meatpacking and processing firms, 1929-75.

<table>
<thead>
<tr>
<th>Original Firm Name (and current owner)</th>
<th>1929</th>
<th>1947</th>
<th>1958</th>
<th>1967</th>
<th>1975</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales</td>
<td>Rank</td>
<td>Sales</td>
<td>Rank</td>
<td>Sales</td>
</tr>
<tr>
<td></td>
<td>(mil $)</td>
<td>(#)</td>
<td>(mil $)</td>
<td>(#)</td>
<td>(mil $)</td>
</tr>
<tr>
<td>Swift &amp; Co. (Esmark)</td>
<td>1,000</td>
<td>1</td>
<td>2,249</td>
<td>1</td>
<td>2,645</td>
</tr>
<tr>
<td>Armour &amp; Co. (Greyhound)</td>
<td>900</td>
<td>2</td>
<td>1,956</td>
<td>2</td>
<td>1,850</td>
</tr>
<tr>
<td>Wilson &amp; Co. (Jones &amp; Laughlin)</td>
<td>310</td>
<td>3</td>
<td>738</td>
<td>3</td>
<td>683</td>
</tr>
<tr>
<td>Cudahy Packing (General Host)</td>
<td>268</td>
<td>4</td>
<td>573</td>
<td>4</td>
<td>369</td>
</tr>
<tr>
<td>John Morrell &amp; Co. (United Brands)</td>
<td>95</td>
<td>5</td>
<td>286</td>
<td>5</td>
<td>402</td>
</tr>
<tr>
<td>Hygrade Food Products</td>
<td>412</td>
<td>4</td>
<td>346</td>
<td>8</td>
<td>388</td>
</tr>
<tr>
<td>Hormel, Geo. A. &amp; Co.</td>
<td>361</td>
<td>7</td>
<td>549</td>
<td>4</td>
<td>996</td>
</tr>
<tr>
<td>Oscar Mayer &amp; Co.</td>
<td>260</td>
<td>8</td>
<td>402</td>
<td>7</td>
<td>1,055</td>
</tr>
<tr>
<td>Iowa Beef Processors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBPXL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kane-Miller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Beef Packers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spencer Foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rath Packing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Standard & Poor's Industry Surveys; Moody's Industrial Manual.
the top four firms were Swift, Armour, Wilson, and Cudahy. This relationship persisted for some time with market shares and rankings fairly stable. It was not until after World War II that this pattern of stability broke down. By the 1960's, several new entrants had begun operations and zoomed straight to the top, joining the elite club of the "Fortune 500" in just a few short years. Firms like Iowa Beef Processors (IBP), American Beef Packers (ABP), Needham Packing, and Spencer Foods enjoyed great success at the expense of the old-timers. Some of the old-line firms have been so stung by these swings in profits and market share that they have begun to withdraw from losing operations. For example, Swift & Co., now owned by Esmark, Inc., announced in 1977 that they would shut about 80% of its broiler, one-third of its carcass beef, and one-fifth of its pork capacity [32, p. 1].

This pattern of decline of the old-line and emergence of the new breed is detailed in Table 3.9. One of the former leaders who fell quicker than the rest is Cudahy, who had slipped to the ninth position in 1967 when it actually sold only about one-half as much as in 1947. The last column in Table 3.9 shows the sales of some of the current leading firms in 1975. A number of the old-line packers are now owned by conglomerates so sales figures should be viewed with caution as it is impossible to separate out sales of meat or beef. In 1975, IBP was unquestionably "the largest beef company in the U.S." [28].

---

1 At that time these four companies accounted for approximately 50 percent of the commercial cattle slaughter [7, p. 47].

2 Some economists have argued that stability of market shares, coupled with relatively high concentration is indicative of a poorly functioning market with either tacit or overt collusion a strong possibility. See Gort [12] and Shepherd [21, p. 131].
were both around the $1 billion level with a majority of their sales in pork and processed meat items. What the data in Table 3.9 serve to underscore is how unstable firm rankings have been recently in the meat industry.¹

**Product Differentiation.**

There are only limited possibilities for product differentiation in meatpacking. Federal beef grading has the effect of homogenizing meat products into broad product classes, e.g., prime, choice, good, so that a single firm would find it difficult to claim that its product is different from others.² Pork and processed meat products have proven to be more amenable to attempts at producer product differentiation. For example, most consumers perceive that there are only a few high-quality brands of bacon. Objectively, it may be the case that the physical characteristics of most brands are nearly identical. But advertising has created this image of differentiability for which

¹Further evidence of instability in the meatpacking industry is afforded by the case of American Beef Packers. Founded in 1965, ABP quickly rose to become one of the nation's largest packers, selling $896 million in 1974. However, in early 1975, ABP filed for relief under Chapter XI of the Federal Bankruptcy Act. Too rapid growth and some questionable business practices were largely responsible for the firm's problems as it narrowly avoided completely shutting down.

²Yield and quality grading is set by USDA standards. Quality is designated by classes: Prime, Choice, Good, Standard, Utility, etc.; and cutability or yield is indicated by a range from 1 (highest) to 5(lowest).
consumers seem willing to pay. Profitability can be substantial when product differentiation is successful. For example, note the president's comment on Esmark's retrenchment plans:

... Swift's processed-meat operations have been doing well, .. . because the branded products provide higher profit margins and significant marketing opportunities (as compared to commodity lines of business). Swift will be spending substantially more money to sell such products. Swift has raised its advertising budget for branded goods 50% to nearly $30 million this year. (32)

Economies of Scale.

The most recent systematic study of economies of scale in cattle slaughtering plants is one prepared for the National Commission on Food Marketing (NCFM) in 1966 [14]. The findings were that labor costs are the predominant factor for all sizes of plants, ranging from 67-70 percent of total cost (excluding the costs of raw material). Long run average costs exhibit economies of scale, decreasing from $10.67 per head for plants killing 20 head per hour to $7.91 per head for the largest plant killing 120 head per hour. Most of the scale economies can be traced to increased efficiency and specialization in labor inputs with larger plants. More intense use of identical items of equipment and sufficient size to warrant use of new equipment items also led to efficiencies [14, pp. 20-23]. Even though these factors were found to exist, it was also noted by the NCFM that:

"...in both cattle and hog slaughtering, economies of scale in plant operation can be achieved by firms with a relatively small share of the national market. Explanations of large firm size must be found elsewhere."

[18, p. 20]
Another source of more up-to-date, but unfortunately sketchy, information is the American Meat Institute [1]. The AMI provides data for four separate classes of meatpacking companies: so-called "national packers" with sales annually greater than $250 million and national product distribution; "regional packers" with sales between $25-250 million; "sectional packers" with sales between $5-25 million, and product distribution usually extending to communities adjacent to where the company is located; and "local packers" with sales less than $5 million and sales limited to the immediate area of company location. Also, data are reported for meat processing firms.

In 1975, wages and salaries for the meatpacking industry accounted for 38.3 percent of total operating expenses (see Table 3.10). Supplies and containers were 17.9 percent; total employee benefits were 11.4 percent.

The apparent discrepancy between the AMI and NCFM figures for labor cost can be reconciled as follows. First and foremost, the NCFM study was originally centered in Los Angeles, California, a high wage area with respect to the rest of the packing industry. Thus, the NCFM figures are biased upwards in terms of the entire U.S. Second, adding the separate AMI amounts for a) wages and salaries and b) employee benefits yields numbers that are more comparable with the NCFM results. Even so there is a rather large difference between the two sources which can only be attributed to the different samples used in each study. The AMI data are probably more representative of the entire population of packing firms since they include more firms in their sample.

Another feature highlighted in Table 3.10 is that local and
<table>
<thead>
<tr>
<th></th>
<th>Meat Packing Companies</th>
<th></th>
<th>Meat Processing Co's (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>National (%)</td>
<td>Regional (%)</td>
<td>Sectional (%)</td>
</tr>
<tr>
<td>Total Operating Expenses</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Wages and salaries</td>
<td>37.2</td>
<td>42.7</td>
<td>45.2</td>
</tr>
<tr>
<td>Employee benefits</td>
<td>11.8</td>
<td>9.7</td>
<td>9.0</td>
</tr>
<tr>
<td>Interest, depreciation, rent, taxes</td>
<td>7.8</td>
<td>7.6</td>
<td>9.0</td>
</tr>
<tr>
<td>Supplies and containers</td>
<td>18.1</td>
<td>15.1</td>
<td>15.7</td>
</tr>
<tr>
<td>All other expenses</td>
<td>25.0</td>
<td>24.9</td>
<td>21.1</td>
</tr>
</tbody>
</table>

Source: American Meat Institute, Financial Facts about the Meat Packing Industry, 1975
sectional packers--those which would tend to have the smallest plants--exhibit comparatively higher labor costs as a percent of total operating expenses. This is further indication that the larger firms (as well as plants) may be able to use labor more efficiently through specialization of labor inputs. Interestingly, the supplies and container expense is relatively much less for the local packers who evidently do much less shipping than their larger competitors.

One final method for determining the incidence of scale economies is provided by the survivor technique. Survivalship patterns for value added by establishment size in Table 3.11 reveal a striking pattern. The smallest size plants (1-9 workers) and the largest category lose substantial ground. The 10-49 and 1,000-2,499 worker plants also slip somewhat in relative positions. Only the groups of establishments with between 50 to 999 workers register gains. It would appear that this middle-ground establishment size of 50-999 employees is where the flat portion of the industry average cost curve lies. Small and very large plants seem to be inefficient by the survivor test.

All of the data examined here on scale economies point in the same direction. There are most likely increasing returns to scale in the meatpacking industry for the fairly small size (perhaps local) packer. These gains in efficiency from larger size peter out at a low level.

The percent change index is an easy guide to shifts in share on a relative basis. It is obtained by dividing the "percent of total" for a given year and size category by the percent of total for 1963 for that category. For example, in 1967 for 500-999 employees, (11.8/13.2) x 100 = 89. Thus the index shows a relative drop of 11% even though there was an absolute increase in value added.
Table 3.11. Value added by manufacture and percent changes in share by establishment size for meatpacking plants (SIC 2011).

<table>
<thead>
<tr>
<th>Establishment size (number of employees)</th>
<th>1963 Value Added (mil $)</th>
<th>1963 Percent of Total (%) (’63=100)</th>
<th>1963 % Change %</th>
<th>1967 Value Added (mil $)</th>
<th>1967 Percent of Total (%) (’63=100)</th>
<th>1967 % Change %</th>
<th>1972 Value Added (mil $)</th>
<th>1972 Percent of Total (%) (’63=100)</th>
<th>1972 % Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>28.4</td>
<td>1.5</td>
<td>100</td>
<td>32.5</td>
<td>1.5</td>
<td>98</td>
<td>25.9</td>
<td>0.9</td>
<td>59</td>
</tr>
<tr>
<td>5-9</td>
<td>32.3</td>
<td>1.7</td>
<td>100</td>
<td>39.6</td>
<td>1.8</td>
<td>105</td>
<td>24.9</td>
<td>0.8</td>
<td>50</td>
</tr>
<tr>
<td>10-19</td>
<td>59.6</td>
<td>3.1</td>
<td>100</td>
<td>56.5</td>
<td>2.5</td>
<td>81</td>
<td>74.1</td>
<td>2.5</td>
<td>80</td>
</tr>
<tr>
<td>20-49</td>
<td>157.7</td>
<td>8.3</td>
<td>100</td>
<td>189.7</td>
<td>8.5</td>
<td>103</td>
<td>225.9</td>
<td>7.6</td>
<td>92</td>
</tr>
<tr>
<td>50-99</td>
<td>164.0</td>
<td>8.6</td>
<td>100</td>
<td>224.5</td>
<td>10.1</td>
<td>118</td>
<td>300.3</td>
<td>10.1</td>
<td>118</td>
</tr>
<tr>
<td>100-249</td>
<td>274.4</td>
<td>14.4</td>
<td>100</td>
<td>323.0</td>
<td>14.5</td>
<td>101</td>
<td>424.0</td>
<td>14.3</td>
<td>99</td>
</tr>
<tr>
<td>250-499</td>
<td>247.3</td>
<td>13.0</td>
<td>100</td>
<td>412.1</td>
<td>18.6</td>
<td>143</td>
<td>647.7</td>
<td>21.8</td>
<td>168</td>
</tr>
<tr>
<td>500-999</td>
<td>252.4</td>
<td>13.2</td>
<td>100</td>
<td>261.2</td>
<td>11.8</td>
<td>89</td>
<td>446.3</td>
<td>15.0</td>
<td>114</td>
</tr>
<tr>
<td>1,000-2,499</td>
<td>340.3</td>
<td>17.8</td>
<td>100</td>
<td>356.2</td>
<td>16.0</td>
<td>90</td>
<td>479.6</td>
<td>16.1</td>
<td>91</td>
</tr>
<tr>
<td>2,500 or more</td>
<td>352.1</td>
<td>18.4</td>
<td>100</td>
<td>325.2</td>
<td>14.6</td>
<td>79</td>
<td>321.4</td>
<td>10.8</td>
<td>58</td>
</tr>
</tbody>
</table>

Establishments, Total: 1,908.3 100.0 -- 2,220.5 100.0 -- 2,970.1 --

The percent change index measures the increase (>100) or decrease (<100) in relative share of total since the base year, 1963.

Also the very largest plants in terms of labor size also seem to be high cost operations. A typical, efficiently run meatpacking plant of say 250-499 workers in 1972 would have made about .3% of total industry sales. The possibility of economies of scale posing an obstacle to entering the industry is extremely limited.

**Capital Requirements.**

The NCFM presented investment costs for cattle slaughtering plants, but the figures pertain to the early 1960's (14, p. 40). The cost estimates for building and equipment ranged from $335,015 to $1.6 million for a variety of plant sizes with the smallest output 20 head per hour and the largest 120 head per hour. The number of workers required to staff these plants ran from 31 for the smallest plant to 174 for the largest plant.

General economic conditions are greatly changed since the NCFM report so the relevance of these investment costs for today's market is doubtful. However, an alternative, less precise procedure is available for estimating capital requirements. Estimates derived from U.S. Bureau of Census data for capital expenditures by size of establishment are
These data show that capital requirements have been advancing rapidly for all sizes of meatpacking plants. The NCFM model plants might have cost from $456,000 to $2.3 million in 1972. The largest plant with over 2,500 workers would have cost approximately $26 million to build and equip in 1972. From the survivor test, the plant size which appears to be most efficient, 250-499 worker, would have required an investment of $5.3 million in 1972.

These Census estimates are simply rough guesses, but they do correspond rather well with data from other sources. For example, Engelman reports in 1975,

We have often said that entry into cattle slaughtering was relatively easy. Economies of scale will usually be accomplished when a plant reaches 100,000 head annual capacity. Such a plant would have cost between $1 million and $1.5 million in 1970, from $10. to $15. for each head handled during the year.... Some of the recently constructed beef slaughtering and fabricating plants have cost in the 20 millions. (8, p. 2)

The estimates in Table 3.12 were derived as follows. The Census only provides data for new capital expenditures by size of plant, i.e., incremental additions to the capital stock. In order to estimate the total value of assets in place it is necessary to know the service life of capital. This was estimated by taking the mean of the ratio of the gross value of fixed assets (for all meatpacking plants) to new capital expenditures for all plants. The mean service life for the period 1962-71 is 11.89 years. This is the number of equal-sized capital outlays that would have to be made in order to replace in any given year the gross value of fixed assets. The data in Table 3.12 were then calculated by multiplying detailed census estimates of new capital expenditures per establishment by 11.89. The resulting estimates are only rough approximations of capital requirements for plant and equipment and may be in error by as much as 20 percent.
Table 3.12. Estimates of Capital requirements\(^1\) per establishment by establishment size for meatpacking plants (SIC 2011).

<table>
<thead>
<tr>
<th>Establishment size (number of employees)</th>
<th>1963 (thous. $)</th>
<th>1967 (thous. $)</th>
<th>1972 (thous. $)</th>
<th>Percent Change, (1967-72) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>76</td>
<td>71</td>
<td>124</td>
<td>75</td>
</tr>
<tr>
<td>5-9</td>
<td>56</td>
<td>38</td>
<td>74</td>
<td>95</td>
</tr>
<tr>
<td>10-19</td>
<td>100</td>
<td>86</td>
<td>147</td>
<td>71</td>
</tr>
<tr>
<td>20-49</td>
<td>259</td>
<td>322</td>
<td>456</td>
<td>42</td>
</tr>
<tr>
<td>50-99</td>
<td>583</td>
<td>447</td>
<td>963</td>
<td>115</td>
</tr>
<tr>
<td>100-249</td>
<td>763</td>
<td>1,696</td>
<td>2,315</td>
<td>36</td>
</tr>
<tr>
<td>250-499</td>
<td>1,712</td>
<td>2,321</td>
<td>5,287</td>
<td>128</td>
</tr>
<tr>
<td>500-999</td>
<td>2,558</td>
<td>2,690</td>
<td>7,854</td>
<td>192</td>
</tr>
<tr>
<td>1,000-2,499</td>
<td>5,333</td>
<td>7,082</td>
<td>12,641</td>
<td>78</td>
</tr>
<tr>
<td>2,500 or more</td>
<td>11,308</td>
<td>9,512</td>
<td>26,396</td>
<td>178</td>
</tr>
<tr>
<td>Average</td>
<td>319</td>
<td>483</td>
<td>806</td>
<td>67</td>
</tr>
</tbody>
</table>

\(^1\) Estimates were derived by multiplying (a) new capital expenditures per establishment by (b) an average of the ratio of the gross value of fixed assets to aggregate new capital expenditures.

Engelman's observations are interesting in several respects. First, his estimate as to where scale economies cease is approximately the same as what the survivor test indicates; in 1972 a plant with 250-499 employees (the optimal size by the survivor test) would have slaughtered about 115,000 head of cattle and calves. Second, the estimates of the capital requirements are comparable with those in Table 3.12. Any difference could be accounted for by the different years of reference: 1970 (Engelman) vs. 1967 and 1972 (Census).

Further corroboration of the estimates in Table 3.12 is provided by Schake et al., (19) who found the investment cost for some fairly small meat processing plants in the early 1960's was between $770,000 and $1.3 million. Also recent issues of a trade magazine (11) report that sausage and meat processing plants that were being built in 1975 cost between $8 million and $13 million.

Another important start-up cost for a potential entrant is the required initial investment in livestock inventory. Census estimates of end-of-year inventories by establishment size range from approximately $5,000 for the smallest plant (1-4 employees) to nearly $16 million for the largest plant (greater than 2,500 workers). The optimal size plant of 250-499 employees held inventories of $1.4 million. If the cost of inventory were added to the estimates in Table 3.12, the total capital requirement for each class would rise by 20 to 30% on average.

1 The plant to which Engelman refers as costing in the "20 millions" is probably a slaughtering/processing facility built by ABP at Dumas, Texas in the early 1970's.
Although many of these estimates are rough approximations, they are accurate enough to make the point: capital barriers are not large in the meatpacking trade. Obtaining $5 to 10 million in financing would be difficult for an individual, but for a going concern already active in the food industry constructing and outfitting an efficient plant would not be difficult to do. These capital requirements (including inventory) are fairly modest in comparison to most manufacturing industries.

**Regulatory Costs**

A number of statutes and regulatory agencies affect competitive conditions in the wholesale meat trade. For example, the Consent Decree of 1920 originally constrained the largest packers from vertically integrating into the cattle raising or retail distribution sectors of the industry. Other relevant laws and regulations are the Packers and Stockyards Act of 1921, uniform grading standards, import quotas, occupational safety and health standards (OSHA), environmental protection guidelines, and the Wholesome Meat Act of 1967. A recent study of the effect of these regulations on the meat industry found that:

1) federal and state agencies spent about $165.3 million in 1975 to enforce the Wholesome Meat Act, and

2) companies spent approximately $42.2 million to comply with the Act (10, p. 8).

These results are a further explanation for the disappearance of many of the least efficient packing plants that occurred after the 1963 Census.
REFERENCES


27. U.S. Senate, "The market functions and costs for food between America's fields and tables", Committee on Agriculture and Forestry, Committee print, March 25, 1975.


Market concentration.

A majority of the statistical studies in the literature have found a positive association between seller concentration and profitability[30]. That is, when concentration increases because there are fewer firms or the market share of the leaders moves up then the profits of the relevant market participants seems to increase, as well. The statistical relationship is often not a strong one, but the theory is generally confirmed nonetheless.

There have been several studies which have specifically analyzed the case of concentration in retail food markets. A fair summary of much of this work is that local retail food markets pose somewhat of a contradiction to the conventional theory. Although there is often relatively high concentration, these markets seem to be relatively competitive.(11,12,15).

Competition in grocery retailing takes place in two distinct markets — first, selling activity is restricted to small geographic areas defined by consumer shopping habits and transportation systems; second, buying activity takes place on a national scale as retail firms compete with one another in their purchases from wholesalers and manufacturers.

The U.S. Bureau of Census takes Standard Metropolitan Statistical Areas (SMSA's) as an approximation for local retail grocery markets. (See Appendix 1 for a study of the relation between concentration and size of market.) In the early post World War II years, concentration rose fairly rapidly, due in part to a large degree of merger activity. See Table 4.1. After 1958, the pace slowed considerably. But by 1972 the simple average
Table 4.1. Local Market Concentration of Grocery Store and Supermarket Sales by 4, 8, and 20 Largest Firms, 263 SMSA's, 1954-72.

Percentage of grocery store sales accounted for in ---

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st to 4th largest</td>
<td>45.5</td>
<td>49.3</td>
<td>50.0</td>
<td>51.1</td>
<td>52.4</td>
</tr>
<tr>
<td>5th to 8th</td>
<td>8.9</td>
<td>10.6</td>
<td>11.9</td>
<td>13.7</td>
<td>14.9</td>
</tr>
<tr>
<td>1st to 8th</td>
<td>54.4</td>
<td>59.9</td>
<td>62.0</td>
<td>64.8</td>
<td>67.3</td>
</tr>
<tr>
<td>9th to 20th</td>
<td>10.1</td>
<td>11.1</td>
<td>12.3</td>
<td>12.9</td>
<td>13.4</td>
</tr>
<tr>
<td>1st to 20th</td>
<td>64.5</td>
<td>71.0</td>
<td>74.3</td>
<td>77.7</td>
<td>80.7</td>
</tr>
</tbody>
</table>

\(^1\) Simple averages for all years reflect SMSA's as defined at that time. Composition change between 1967 and 1972, due to the inclusion of new SMSA's and the combination of older SMSA's, is not significant.

four-firm concentration ratio across 263 SMSA's was 52.4 percent up from 45.5 percent in 1954. The 5th to 8th largest and 9th to 20th largest local firms have also registered increases in market share over this period.

The trend in the local market data can be compared with trends in the national market share of the leading grocery chains, as shown in Table 4.2. Although this type of data is more an indicator of buying strength in terms of the chains' purchasing and wholesaling activities, it is not entirely unrelated to conditions in local markets. Table 4.2 shows a nearly static level of four firm concentration over the 1948-70 period. In 1972, there was a precipitous drop in national market concentration. The troubles encountered by A&P in the early 1970's were especially severe, e.g. the disastrous WEO program. By 1975 it was estimated that A&P's share of the national market had fallen to 4.9 percent [32,p.11]. One presumes that A&P's poor performance was a combination of bad luck and poor management, cf. Joskow's description of Westinghouse's problems [33].

While A&P's share of the national market was dipping during the 1960's, the shares of the other top firms (recently they have been Safeway, Kroger, and Amerian) were increasing. The most rapid growth was by the 5th to 8th and 9th to 20th largest chains which approximately doubled and tripled their market shares, respectively, over the 1948-70 period. All groups suffered a decline in 1972. Reasons for this include retail food price controls, relative attractiveness of smaller convenience food store outlets and eating food away from home.
### Table 4.2. National Market Share of 20 Leading Grocery Chains, Selected Years, 1954-72

<table>
<thead>
<tr>
<th>Rank of Chains</th>
<th>Share of total grocery store sales in [in percent]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st to 4th largest</td>
<td>20.1</td>
</tr>
<tr>
<td>5th to 8th</td>
<td>3.6</td>
</tr>
<tr>
<td>1st to 8th</td>
<td>23.7</td>
</tr>
<tr>
<td>9th to 20th</td>
<td>3.2</td>
</tr>
<tr>
<td>1st to 20th</td>
<td>26.9</td>
</tr>
<tr>
<td>A &amp; P</td>
<td>10.7</td>
</tr>
</tbody>
</table>

Source: National Commission on Food Marketing, Organization and Competition in Food Retailing, June 1966; estimates for 1967, 1969, and 1970 were completed from sales of food chains, and total sales of grocery stores reported by the Bureau of Census, Census of Business Retail Trade and Annual Retail Trade Reports; all as reported in Hearings before Joint Economic Committee, U.S. Congress, "Food Retailing and Processing Practices", May 21, 1974, p. 46; estimates for 1972 are from U.S. Bureau of Census, Census of Retail Trade, 1972, Establishment and Firm Size (RC72-S-1), p. 1-3.
Product Differentiation

Bain considered product differentiation to be the most important structural factor which could raise prices high in relation to costs. Yet, the literature and available data on advertising effectiveness in the food industry is extremely scant. Presumably all supermarkets would like to have an image in the consumers' mind which sets them apart from their competitors and for which the consumer is willing to pay. However, since there are so many common products which all food stores trade in, the possibilities for building a store image and capitalizing on product differentiation seem relatively scant. Even the practice of private-branding now seems to be regarded by professional economists as another instance of the competitive nature of the retail food trade [19, p.200].

Although they offer no empirical support for their claims, Marion and Mueller state that significant advertising advantages are conferred on large firms in local retail markets.

Real scale economies in advertising accrue to establish chains with a large local market share. Since advertising expenditures are spread over larger sales volumes, advertising expenses per dollar of sales are lower.

Pecuniary scale economies accrue from the inverse relationship that exists between the total volume of company advertising and the advertising rates charged by the media. Large established firms in a market often realize volume discounts from newspapers which cannot be achieved by a new entrant or small scale competitors (32, pp. 24-25).

The argument, although not without basis, seems overstated. Barriers to entry.

Although it is important, not a great deal is known about conditions under which firms enter and leave the retail food industry. About 40 years ago, one analyst reported that

There is no obstacle to entrance to the field. Capital requirements are low. Quarters may be rented cheaply ... The necessary equipment is inexpensive and can be bought at secondhand, Stocks of goods are abundant; sources of supply are numerous and widely
scattered; credit is readily available . . . Technical training and managerial experience are not required. {31}

In the 1950's much the same was true, as it was noted that "... in the retail food trade, entry is easy, both in the same location and from the fringes." [1] However, structural conditions can change because in 1966 a special report on the industry by the National Commission on Food Marketing (hereafter NCFM) concluded that "...it is quite apparent that today entry barriers are substantial, and that rather than causing erosion of existing levels of concentration, the conditions of entry may well contribute to further increases." [14]

**Economies of scale.**

The term economies of scale refers to the relationship between a firm's costs and its rate of output. In a given industry, if large firm's are observed to have lower unit costs than small firms then economies of scale might explain the difference. Economies of scale can derive from a number of sources and can pertain to either the firm or the plant. Most studies of American industry have found that economies of scale exist up to some point, but then disappear as the opportunities for making further cost reductions through increased size are exhausted [12, pp. 72-130]. The critical question here is whether the minimum efficient firm size is small or large in relation to industry demand. If the minimum efficient size is large, then economies of scale can effectively impede the entry of other firms.

There are several techniques available for judging the extent of scale economies. None of these measures are foolproof, and it is not unreasonable to use two or more in conjunction with one another.

The first method considered for determining optimal firm or plant size is the survivor technique. [23]. This is a Darwinian concept based upon the proposition that the competition of different size firms sifts out the
more efficient enterprises. To employ the technique, one simply classifies the firms in an industry by size and calculates the share of industry output coming from each class over time. If a given class' share is falling, it is relatively inefficient, and in general is more inefficient the more rapidly the share falls. Conversely, a class whose share is rising must be at or near optimum size. Applications of the survivor test in several industries have found that a broad range of firm and plant sizes are close to minimum efficient size. This result is taken to indicate that unit cost curves are fairly flat over a large range of sizes.

In trying to apply the survivor technique to the retail food industry two issues emerge. First, one would like to evaluate economies at both the firm and plant level. Second, one must be careful about defining the market in which the firms compete—it could be national, regional, or local in nature.

Let us first take a look at firm size at the national level. Table 4.3 shows the survivalship patterns in the grocery store trade over the period 1963-72. The market share index clearly indicates that single-store operations are subject to strong diseconomies of small scale, since single-unit firms dropped over 25% of their grocery market share in just a ten year period. The next two smallest size categories, 2 to 5 and 6 to 10 establishment firms, grew at a fairly slow rate, with the former even declining slightly in 1967. This would indicate that the 2 to 10 store firms are probably at the lower boundary of the efficient size range. The large number of firms in the 3 categories covering 11 through 100 stores all exhibited steady growth over the period, thus underscoring the breadth of the range of efficient firm sizes. Firms
Table 4.3. Survivalship patterns for single and multiunit retail grocery store firms.

<table>
<thead>
<tr>
<th>Number of stores owned by firm</th>
<th>1963</th>
<th>1967</th>
<th>1972</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales (mill.)</td>
<td>Percent</td>
<td>Market Share Index ('63=100)</td>
</tr>
<tr>
<td>Single units</td>
<td>22,677</td>
<td>43.1</td>
<td>100</td>
</tr>
<tr>
<td>2-5 establishment multiunits</td>
<td>3,630</td>
<td>6.9</td>
<td>100</td>
</tr>
<tr>
<td>6-10 establishment multiunits</td>
<td>1,538</td>
<td>2.9</td>
<td>100</td>
</tr>
<tr>
<td>11-25 establishment multiunits</td>
<td>2,192</td>
<td>4.2</td>
<td>100</td>
</tr>
<tr>
<td>26-50 establishment multiunits</td>
<td>1,659</td>
<td>3.2</td>
<td>100</td>
</tr>
<tr>
<td>51-100 establishment multiunits</td>
<td>2,752</td>
<td>5.2</td>
<td>100</td>
</tr>
<tr>
<td>101 or more establishment multiunits</td>
<td>18,118</td>
<td>34.5</td>
<td>100</td>
</tr>
<tr>
<td>Total Grocery Store Sales</td>
<td>52,566</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

with over 100 stores showed an erratic growth trend suggesting that they may be at the upper boundary of optimal sizes, with some firms in this group likely experiencing diseconomies of large scale, e.g. A&P.

The other side of the coin is the optimal size of plant or store. Table 4.4 shows that only the stores in the topmost category of greater than $1 million in annual sales (or approximately $20,000 in weekly sales) were realizing increasing returns to scale. The striking fact is that all other size categories declined significantly in their market share over the decade 1963-72. The pattern of decline in market share was steepest for the smallest stores suggesting that these are the highest unit cost operations in the industry, and probably primarily owned by single-unit firms. The data also suggest that the difficulties exhibited by some of the largest firms, as noted in Table 4.3, might stem from their ownership of numerous stores in the inefficient size range.

There are a number of factors that limit the usefulness of the survivor technique as applied in Table 4.4. An especially troubling problem can be price level changes which distort underlying shifts in efficient firm sizes. As noted above, the share of stores doing at least $1 million per year ($20,000 weekly) went from 53 percent in 1963 to 72 percent in 1972. Now, a large part of the shift was due simply to price changes. The consumers price index for food rose by 35.4 percent over the ten years. Hence, a store doing $740,000 in 1963 would be doing about $1 million in 1972, even if it sold exactly the same quantities of goods. Therefore roughly half the stores in the category "$0.5 to 1.0 million" must have found themselves in the higher category (one million and over)
### Table 4.4. Survivalship Patterns for Grocery Stores by Annual Sales Size

<table>
<thead>
<tr>
<th>Annual Sales of</th>
<th>1963</th>
<th>1967</th>
<th>1972</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales ($000,000)</td>
<td>Market Share Index (1963=100)</td>
<td>Percent (2)</td>
<td>Sales ($000,000)</td>
</tr>
<tr>
<td>$5 million or more</td>
<td>26,405</td>
<td>52.7</td>
<td>100</td>
</tr>
<tr>
<td>$2 to 4 million</td>
<td>8,035</td>
<td>16.1</td>
<td>100</td>
</tr>
<tr>
<td>$1 to 2 million</td>
<td>3,306</td>
<td>7.0</td>
<td>100</td>
</tr>
<tr>
<td>$0.5 to 1 million</td>
<td>6,480</td>
<td>12.9</td>
<td>100</td>
</tr>
<tr>
<td>$0.3 to 0.5 million</td>
<td>3,162</td>
<td>6.3</td>
<td>100</td>
</tr>
<tr>
<td>$0.2 to 0.3 million</td>
<td>1,400</td>
<td>2.8</td>
<td>100</td>
</tr>
<tr>
<td>$0.1 to 0.2 million</td>
<td>846</td>
<td>1.1</td>
<td>100</td>
</tr>
<tr>
<td>$0.1 to 0.08 million</td>
<td>382</td>
<td>0.8</td>
<td>100</td>
</tr>
<tr>
<td>less than $0.1 million</td>
<td>107</td>
<td>0.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Total for establishments operated entire year: 50,042 100.0 65,074 100.0 87,441 100.0

in 1972, and this might account for as much as seven percentage points of the total gain of 20 percentage points. But clearly most of the gain was "real" not apparent. For if there had been only a change by reason of inflation, every class would be losing to the next higher class, but gaining from the next lower, with net losses only at the extreme lower end, and a net gain only at the upper extreme. In fact, we see a net loss in every size class but the over $1 million.

What does all this tell us about economies of scale in the retail food industry? The data indicate what most industry people have known for some time--that a substantial volume of sales is a critical element in maintaining store costs at an efficient level. No matter whether a firm is composed of just 2 or 3 stores or well over 100, per store annual sales volume must be over the $1 million mark in order to realize economies of scale. There are several reasons why this criterion most likely does not pose a large deterrent to entry into the retail grocery market. First, this annual sales hurdle is a small fraction of almost any local market. For example, it may be estimated that close to one fourth of all the SMSA's had food store sales greater than $400 million in 1974 prices [25]. Thus, a new store doing $1 or 2 million per year would be less than 0.5 percent of many large metropolitan markets. Second, the facts show that firms of nearly all size categories were able to survive. Also, it should be noted that more than a fourth of food store sales in 1972 were by stores doing less than $1,000,000 (or $20,000) in annual (or weekly) sales.
Before fully accepting this conclusion however, we should check these results by other methods of evaluating the extent of economies of scale. Two alternatives are to use profitability data by size of firm or to rely on econometric or engineering cost studies which typically deal with size of plant. Unfortunately there are problems associated with each of these alternatives.

Profitability data are available but only for the largest corporate chains. Thus, the majority of the size distribution of firms is unavailable and one is left with little indication of the optimal firm size. Given this caveat, the profit data are shown in Table 4.5. Clearly 1972 was a bad year for nearly all food chains regardless of size. In other years, the smaller size categories seem to do at least as well as the larger ones thereby offering support for the conclusion reached on the basis of the survival tests. This finding also agrees with the NCFM [14, p. 304] which concluded in 1966 that there was little difference in earnings between medium- and large-size chains.

The problem with statistical or engineering cost studies is that they are very difficult to do without large amounts of detailed data. Often aggregation and accounting problems can undermine the most well-intentioned efforts. Rather than launching into a study of this nature, we are forced to rely on the results of an earlier study whose conclusions are presumably still valid today. On the basis of fitting a variety of statistical cost functions to data for thousands of stores, the NCFM reported in 1966 that:
Table 4.5. Net profits after income taxes as percent of stockholders' equity for leading food chains by size.*

<table>
<thead>
<tr>
<th>Percent of Industry Market Share</th>
<th>1958 Unweighted Mean</th>
<th>1963 Unweighted Mean</th>
<th>1967 Unweighted Mean</th>
<th>1972 Unweighted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Over 5%</td>
<td>13.7 2</td>
<td>10.3 1</td>
<td>10.8 2</td>
<td>15.0 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3.2) (2)</td>
</tr>
<tr>
<td>2.0-5.0%</td>
<td>12.4 2</td>
<td>10.3 5</td>
<td>8.0 3</td>
<td>11.4 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(9.3) (6)</td>
</tr>
<tr>
<td>1.0-less than 2.0%</td>
<td>15.4 6</td>
<td>12.0 4</td>
<td>12.8 4</td>
<td>8.4 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.5) (6)</td>
</tr>
<tr>
<td>0.6-less than 1.0%</td>
<td>10.6 1</td>
<td>12.0 3</td>
<td>17.4 7 (14.2) (8)</td>
<td>11.0 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(8.3) (5)</td>
</tr>
<tr>
<td>0.4-less than 0.6%</td>
<td>13.1 2</td>
<td>12.2 2</td>
<td>12.1 3</td>
<td>10.8 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(8.3) (5)</td>
</tr>
<tr>
<td>0.2-less than 0.4%</td>
<td>17.8 2</td>
<td>12.7 6</td>
<td>13.3 9</td>
<td>6.8 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.7) (12)</td>
</tr>
<tr>
<td>less than 0.2%</td>
<td>-- 0</td>
<td>18.0 1</td>
<td>14.4 5</td>
<td>12.8 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(7.4) (9)</td>
</tr>
<tr>
<td>Total Weighted Average</td>
<td>13.5 30</td>
<td>10.8 30</td>
<td>10.6 46</td>
<td>5.8 46</td>
</tr>
<tr>
<td>All Manufacturing Average</td>
<td>8.6</td>
<td>10.3</td>
<td>11.7</td>
<td>10.6</td>
</tr>
</tbody>
</table>

* Numbers in parenthesis include loss.

Sources: Data for 1958 and 1963 are from National Commission on Food Marketing, technical study No. 7, Organization and Competition in Food Retailing, June 1966, pp. 290-293.

1.) store size has little effect on store costs, but
2.) store utilization has a very significant effect on store costs [14, p. 140].

What this means is that larger stores did not tend to have larger sales per square foot than smaller stores. According to the NCFM, the optimal size store in 1966 was approximately 16,000 square feet of selling area.

The practical result of all this is that economies of scale at the store level are most likely not large in the industry, but that they do exist. Given the fairly narrow industry margin on sales, this cost situation breeds extensive promotional activity to increase volume and thereby bring costs in line and improve profits [14, p. 149].

**Absolute cost requirements.**

A second major barrier to entry is the possibility that large firms may have greater access to capital markets than their smaller rivals. If this were true then financing new plant and equipment expenditures would be cheaper for larger firms in terms of both lower debt costs and lower equity costs. Clearly the capital cost barrier to entry is closely tied to the minimum efficient scale. For example, several hundred million dollars are required to enter either the steel or automobile industry at an efficient size. This scale factor in conjunction with possible capital market imperfections make it difficult to enter these industries.

Little is known about capital barriers in the retail food trade, but the available evidence suggests that relatively small firms would face only minor difficulty in raising the funds required to enter the
industry. First, one need not build new stores at all because there is an active "second-hand" market in food stores. For 1974, over 80% of the new conventional supermarkets opened were leased from independent landlords [24, p. 71]. Also, the Progressive Grocer noted that chains owned more than 80% of the 3,000 supermarkets closed in 1975. Of that total number nearly a third were reopened with the overwhelming majority under the new management of an independent grocer [21, p. 131].

A second reason why capital costs may not be a large barrier to entry is that the average investment and building cost figures are simply not very large. These data are shown in Table 4.6. Capital investment which includes the cost of land for the typical supermarket averaged about $650,000 over the first part of the 1970's. As of 1974, the typical conventional super had approximately 25,500 square feet totally, with 18,500 square feet devoted to selling or customer space [24, p. 48]. To determine the total investment per store required to enter the industry one would also have to estimate the cost of opening inventory which is taken to be approximately $210,000. (See Appendix 2.) Thus, the total per store investment for a new entrant to the supermarket industry in 1974 would have been about $870,000, which is a 45% increase over comparable data for 1964 [14, p. 154]. Over this same period, the price index for nonresidential investment rose by approximately 57 percent [5, p. 174]. This would indicate that after allowance for price inflation, the average capital required for a new store did not increase, but rather declined over this period.
Table 4.6. **Capital requirements for conventional supermarkets.**¹

<table>
<thead>
<tr>
<th>Year</th>
<th>Capital Investment ²</th>
<th>Building Cost³</th>
<th>Square Feet of Selling Area</th>
<th>Square Feet of Total Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>$627,000</td>
<td>$336,490</td>
<td>14,775</td>
<td>20,000</td>
</tr>
<tr>
<td>1972</td>
<td>$530,580</td>
<td>$388,000</td>
<td>17,000</td>
<td>24,038</td>
</tr>
<tr>
<td>1973</td>
<td>$731,490</td>
<td>$426,000</td>
<td>18,670</td>
<td>25,378</td>
</tr>
<tr>
<td>1974</td>
<td>$655,050</td>
<td>$435,851</td>
<td>18,487</td>
<td>25,492</td>
</tr>
</tbody>
</table>

**Source:** Supermarket Institute, *Facts about new supermarkets opened in 1974.*

---

¹ A supermarket is a departmentalized food store with sales of at least $20,000 weekly. Conventional supers are stores with most of the selling area devoted to food.

² Capital investment includes the cost of land, building, store equipment and fixtures, but excludes opening inventory and all operating start-up expense.

³ Building costs include the cost of air conditioning, but excludes the cost of land, parking lot, store equipment and fixtures, coolers and sprinkler system.
Recall however that the survivor tests indicated that single store operations exhibit diseconomies of scale. So, in order to compete with the chains an entrepreneur might have to operate as many as 6 to 10 supermarkets. Under these assumptions, the total initial investment including inventory for the firm would range from approximately $5.2 to $8.7 million. Now suppose further that this firm were to make the average amount of sales for new openings in its 6 to 10 stores. Then firm sales in 1974 would have been between $24.6 and $41.0 million. In the Rhode Island SMSA, which was the smallest of the top fifty grocery markets in 1974, this level of firm sales would have yielded the firm as high as an 11.5 percent share of the food store market. At this scale the firm would have been among the top 5 or 6 competitors in this local market area.

Although these data are estimates, they show that capital costs are probably not an insurmountable barrier for most prospective grocery firms especially when compared to more concentrated industries like steel or automobiles. Nonetheless for the very small operator, a several million dollar initial investment coupled with the minimum efficient size relative to the market may be a large disincentive to entry. Yet, even in this case the potential entrant need not supply all of his own capital equipment and merchandise. Many firms lease the building, its equipment, and the merchandise from suppliers. A 1965 study of independent supermarkets doing between $20,000 and $40,000 in sales per week showed that on average they owned only 39 percent of the assets, not including land and buildings, that they used [17, p. 55]. Also the example assumed that 6 to 10 stores
was the minimum efficient size. In many SMSA's, firms with as few as 2 or 3 stores have survived and been profitable. Thus, the assumed required complement of stores may have been arbitrarily high, and entry may be easier than the estimates show.

**Legal restraints.**

One of the most powerful conditioning factors on the nature of a market is a legal restriction which prohibits firms from engaging in certain buying or selling activities. The U.S. patent law and anti-trust statutes are forces which shape the market structure of nearly every U.S. industry. Patents are typically provided in order to encourage innovative activity and commercial application of inventions. Protection is granted to inventors in the form of exclusivity rights to enter into the production and sale of patented products or processes. On the other hand, the U.S. antitrust system is designed to promote competition in part by reducing the size of entry barriers. Under the broad outlines of primarily the Sherman and Clayton Acts the government most often attacks cases dealing with price fixing, attempts to monopolize, uncompetitive mergers, and other methods of "unfair competition."

It is safe to say that the effect of the patent system on the food trade has been minimal. Many stores probably copyright their name and perhaps some of their private labels. However, the economic effects of these legalistic attempts at product differentiation are judged to be extremely small.
It is in the antitrust area that retail food market structures have been significantly impacted. Perhaps the greatest effects have been under the Robinson-Patman Act of 1936 which amended section 2 of the Clayton Act in order to outlaw price discrimination. Under Robinson-Patman a seller "discriminates" if he charges two customers different prices for "goods of like grade or quality," although he can justify his "discrimination" if he can show that is it no greater than the differences in his costs of supplying the two accounts [29, p. 244-45]. To an economist this is not discrimination at all but simply what one would expect in purely competitive situations, i.e., that prices reflect costs or more to the point that price equal marginal cost. In the legal realm however, the seller can only be sure that he is within the law if he charges the same price to all customers regardless of cost—thereby discriminating (in an economic sense) against low cost accounts.

The A&P case of the late 1940's [26], is the best-known of the price discrimination cases brought within the retail grocery industry. The government charged that A&P extracted preferential and illegal discounts from its suppliers and cross subsidized losing operations. Although the economic merits of this case are the subject of a lengthy debate [1, 8], A&P was convicted and fined $170,000 as well as required to abandon all of its interfirm wholesaling activities. Since that time A&P and other large buyers of food products, e.g., independent wholesalers, have not been allowed to receive price concessions even if their large purchases lowered the unit costs of the suppliers. Enforcement of the antitrust statutes in this way economically discriminates against the
large buyer and affects the structure of the retail market. Some econo-
mists feel that this pattern of enforcement tends to protect inefficient
distributors and possibly lessens competition at the manufacturing level
[11, 29].

Another important antitrust activity in this industry deals with
mergers, as covered under section 7 of the Clayton Act as amended in 1950
by the Celler-Kefauver Act. A large amount of the increase in local
market concentration up through 1963 (see section above) was the re-
sult of a very strong horizontal merger movement. During the period
1949-64, grocery chains made 621 acquisitions of enterprises with total
sales of over $4.5 billion. The 20 largest firms were the most active;
in total they acquired 297 firms with a combined sales value of $3.1 bil-
lion, or nearly 70 percent of the sales of all acquisitions made by chains
during the 1949-64 period [14, p. 103].

Responding to the resulting increases in local market concentration,
the Justice Department and Federal Trade Commission increased industry
surveillance. And in 1960, the famous Von's Grocery case [27] was brought
by the Justice Department in an attempt to stop a merger. Von's Grocery
Co., the third largest chain in the Los Angeles market, with a 4.7 percent
share, acquired Shopping Bag Food Stores, the sixth largest retailer.
Together the firms controlled 7.5 percent of the grocery sales in the
area, making them second only to Safeway who had 8 percent. The Supreme
Court voted 6-to-2 to reverse a lower court ruling in favor of the merger.
The majority opinion demonstrated a great concern with the ultimate effect
that the merger would have on future concentration and competition within the Los Angeles market.

After the Von's decision, the FTC announced in 1967 a set of guidelines governing proposed mergers in the food distribution industry. Mergers would be challenged among food chains in which combined sales exceeded $500 million or with a combined market share over 5%. Also, all chains with sales over $100 million were required to notify the commission in advance of any prospective merger. This type of policy has effectively choked off any sizable merger activity within the industry since that time.

**Industry growth rates and size and type of business.**

The rate of growth of demand for an industry's product can have at least two distinct effects on market structure. First, depending on how rapidly technological advances are occurring, market growth can determine how many firms (or plants) of optimal scale can exist at any particular point in time. Several statistical studies in the literature have found that increases in industry output have been associated with modest, but perceptible, reductions in concentration [22, pp. 88-90]. A second, related effect is that market growth can encourage the entry of new competitors to the industry.

Both of these factors come into play in the retail food industry as they in part determine the ease of entry and the observed levels of concentration. In reviewing the historical pattern of grocery market growth rates it will be helpful also to analyze how various segments of the industry have grown and/or declined.
Aggregate food sales generally grow at about the same rate as consumer income. Table 4.7 shows that constant dollar sales of all grocery stores increased by an average of 3.8 percent per annum over the period 1947-72. During that time, chain stores' sales tripled, affiliated independents' nearly quadrupled, but unaffiliated independents' halved.\(^1\) This rapid expansion of the chains and affiliated independents has been attributed to the lower prices and better service of these firms in comparison with the typically small unaffiliated independent [14, p. 33]. Much of this advantage no doubt stems from the increasing returns to scale to which single-unit and smaller firms are subject. However, all of this growth has not been accounted for by the largest stores and firms. Supermarkets, i.e., stores doing over one million dollars in annual sales, controlled about 72 percent of the grocery market in 1975 [21, p. 75]. The remainder of the market is held by small convenience stores which generally maintain high margins and stay open for long hours each day. These outlets have staged somewhat of a resurgence since the saturation of the market by the large stores in the 1960's.

The total number of grocery stores has declined markedly since the World War II era. Table 4.8 shows that the number of chain stores dropped by 55 percent from 1940 to 1956-7, then climbed again to where the 1972 total was about equal to 1940. The number of independent stores has steadily dropped and is far down from the 1940 levels.

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\(^1\) Chains are currently defined by the Department of Commerce as firms which operate 11 or more stores; before 1952 the cutoff was 4 or more stores. Independents are firms with fewer stores than chains. Affiliated independents are retailers who are either voluntary or cooperative members of large wholesale buying and merchandising groups.
Table 4.7. Constant (1967) Dollar Sales (000,000's) of Retail Chains, Affiliated Independents, and Unaffiliated Independents, 1947-72.

<table>
<thead>
<tr>
<th>Year</th>
<th>Chain Sales</th>
<th>Chain %</th>
<th>Affiliated Sales</th>
<th>Affiliated %</th>
<th>Unaffiliated Sales</th>
<th>Unaffiliated %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>13,290</td>
<td>40.5</td>
<td>9,210</td>
<td>28.1</td>
<td>10,272</td>
<td>31.3</td>
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<tr>
<td>1948</td>
<td>12,432</td>
<td>38.6</td>
<td>10,195</td>
<td>31.6</td>
<td>9,541</td>
<td>29.6</td>
</tr>
<tr>
<td>1949</td>
<td>14,415</td>
<td>41.1</td>
<td>11,954</td>
<td>32.8</td>
<td>10,812</td>
<td>29.7</td>
</tr>
<tr>
<td>1950</td>
<td>13,619</td>
<td>37.4</td>
<td>12,437</td>
<td>33.9</td>
<td>10,263</td>
<td>27.9</td>
</tr>
<tr>
<td>1951</td>
<td>13,973</td>
<td>38.1</td>
<td>13,818</td>
<td>35.5</td>
<td>11,932</td>
<td>28.5</td>
</tr>
<tr>
<td>1952</td>
<td>13,842</td>
<td>35.4</td>
<td>14,073</td>
<td>35.8</td>
<td>12,399</td>
<td>27.8</td>
</tr>
<tr>
<td>1953</td>
<td>15,036</td>
<td>36.3</td>
<td>15,929</td>
<td>35.8</td>
<td>12,500</td>
<td>27.8</td>
</tr>
<tr>
<td>1954</td>
<td>16,152</td>
<td>36.1</td>
<td>16,347</td>
<td>37.0</td>
<td>12,633</td>
<td>24.4</td>
</tr>
<tr>
<td>1955</td>
<td>17,477</td>
<td>36.1</td>
<td>17,297</td>
<td>37.0</td>
<td>12,832</td>
<td>24.4</td>
</tr>
<tr>
<td>1956</td>
<td>19,347</td>
<td>37.0</td>
<td>21,027</td>
<td>44.1</td>
<td>9,825</td>
<td>18.8</td>
</tr>
<tr>
<td>1957</td>
<td>19,432</td>
<td>36.1</td>
<td>24,096</td>
<td>44.8</td>
<td>10,175</td>
<td>18.9</td>
</tr>
<tr>
<td>1958</td>
<td>20,207</td>
<td>37.6</td>
<td>24,474</td>
<td>45.5</td>
<td>9,063</td>
<td>16.8</td>
</tr>
<tr>
<td>1959</td>
<td>21,404</td>
<td>37.6</td>
<td>27,178</td>
<td>47.8</td>
<td>8,274</td>
<td>14.5</td>
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<tr>
<td>1960</td>
<td>22,199</td>
<td>37.8</td>
<td>28,841</td>
<td>49.1</td>
<td>7,664</td>
<td>13.0</td>
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<tr>
<td>1961</td>
<td>23,642</td>
<td>36.3</td>
<td>29,483</td>
<td>43.1</td>
<td>6,907</td>
<td>11.5</td>
</tr>
<tr>
<td>1962</td>
<td>25,741</td>
<td>41.1</td>
<td>30,550</td>
<td>48.8</td>
<td>6,199</td>
<td>9.9</td>
</tr>
<tr>
<td>1963</td>
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<td>41.4</td>
<td>30,479</td>
<td>47.7</td>
<td>6,879</td>
<td>10.7</td>
</tr>
<tr>
<td>1964</td>
<td>27,713</td>
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<td>32,259</td>
<td>48.3</td>
<td>6,711</td>
<td>10.0</td>
</tr>
<tr>
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<td>28,798</td>
<td>41.7</td>
<td>33,662</td>
<td>48.8</td>
<td>6,647</td>
<td>9.3</td>
</tr>
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<td>1966</td>
<td>29,599</td>
<td>43.2</td>
<td>33,002</td>
<td>48.2</td>
<td>5,824</td>
<td>8.5</td>
</tr>
<tr>
<td>1967</td>
<td>30,940</td>
<td>42.7</td>
<td>35,280</td>
<td>48.6</td>
<td>6,226</td>
<td>8.5</td>
</tr>
<tr>
<td>1968</td>
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<td>45.1</td>
<td>33,985</td>
<td>46.1</td>
<td>6,383</td>
<td>8.6</td>
</tr>
<tr>
<td>1969</td>
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<td>46.5</td>
<td>34,170</td>
<td>45.4</td>
<td>5,949</td>
<td>7.9</td>
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<td>47.5</td>
<td>34,247</td>
<td>44.5</td>
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</tr>
<tr>
<td>1971</td>
<td>39,086</td>
<td>48.9</td>
<td>34,750</td>
<td>43.5</td>
<td>5,942</td>
<td>7.4</td>
</tr>
<tr>
<td>1972</td>
<td>40,229</td>
<td>48.8</td>
<td>36,135</td>
<td>43.9</td>
<td>5,905</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Table 4.8. Number of Chain, Affiliated Independent, and Unaffiliated Independent Stores, 1940-72.

<table>
<thead>
<tr>
<th>Year</th>
<th>Chain Stores</th>
<th>Chain %</th>
<th>Affiliated Stores</th>
<th>Affiliated %</th>
<th>Unaffiliated Stores</th>
<th>Unaffiliated %</th>
</tr>
</thead>
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<td>108,750</td>
<td>24.3</td>
<td>296,250</td>
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</tr>
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<td>8.9</td>
<td>108,750</td>
<td>24.4</td>
<td>296,250</td>
<td>66.5</td>
</tr>
<tr>
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<td>8.6</td>
<td>100,000</td>
<td>23.7</td>
<td>284,000</td>
<td>67.5</td>
</tr>
<tr>
<td>1943</td>
<td>34,400</td>
<td>8.9</td>
<td>92,000</td>
<td>23.9</td>
<td>258,000</td>
<td>67.1</td>
</tr>
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<td>92,000</td>
<td>23.9</td>
<td>258,000</td>
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<td>30.4</td>
<td>253,000</td>
<td>63.1</td>
</tr>
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<td>30.9</td>
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<td>100,000</td>
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<td>5.4</td>
<td>101,000</td>
<td>29.4</td>
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<td>84,000</td>
<td>32.3</td>
<td>156,000</td>
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</tr>
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<td>78,000</td>
<td>31.3</td>
<td>152,000</td>
<td>61.0</td>
</tr>
<tr>
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<td>8.7</td>
<td>75,500</td>
<td>32.2</td>
<td>138,500</td>
<td>59.0</td>
</tr>
<tr>
<td>1963</td>
<td>21,000</td>
<td>9.0</td>
<td>75,000</td>
<td>32.4</td>
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<td>58.4</td>
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<td>10.0</td>
<td>76,000</td>
<td>33.5</td>
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</tr>
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<td>11.0</td>
<td>77,000</td>
<td>33.8</td>
<td>125,000</td>
<td>55.0</td>
</tr>
<tr>
<td>1967</td>
<td>27,670</td>
<td>12.2</td>
<td>79,000</td>
<td>35.0</td>
<td>119,000</td>
<td>52.7</td>
</tr>
<tr>
<td>1968</td>
<td>28,800</td>
<td>12.6</td>
<td>80,500</td>
<td>35.4</td>
<td>117,500</td>
<td>51.8</td>
</tr>
<tr>
<td>1969</td>
<td>30,850</td>
<td>14.0</td>
<td>74,480</td>
<td>34.0</td>
<td>113,520</td>
<td>51.8</td>
</tr>
<tr>
<td>1970</td>
<td>34,200</td>
<td>16.4</td>
<td>69,400</td>
<td>33.3</td>
<td>104,600</td>
<td>50.2</td>
</tr>
<tr>
<td>1971</td>
<td>36,670</td>
<td>17.9</td>
<td>66,430</td>
<td>32.4</td>
<td>101,570</td>
<td>49.6</td>
</tr>
<tr>
<td>1972</td>
<td>38,850</td>
<td>19.3</td>
<td>65,600</td>
<td>32.6</td>
<td>96,400</td>
<td>47.9</td>
</tr>
</tbody>
</table>

*Through 1951 chains were considered to be firms operating 4 or more stores; after 1951 chains were those operating 11 or more stores.

Source: Progressive Grocer, April 1976, p. 76.
In Table 4.9 data for sales per store show an interesting pattern. After a steep rise through 1964, the chains' average constant-dollar sales per store have dropped in every year but one, and in 1973 it was below the one million dollar level for the first time since 1955 [27, pp. 75-76]. In contrast, the sales per store of the affiliated independents have grown steadily since 1940, by a factor of approximately 6, and in 1972 it was about 55 percent of the chain average.

In the total national sales market, relative growth rates have varied widely. Since the 1964 high point in sales per store, the corporate chains have increased their share, from 42 to 49 percent, while the affiliated independents have dropped from 48 to 44 percent, and the unaffiliated have skidded from 10 to 7 percent. Considered with the changes in average sales per store, these numbers indicate that some of the affiliated independents have become corporate chains, or are acquiring or being acquired by them. That would account for the decreasing average size of store among chains. Yet the largest affiliated independent stores are not the ones who have moved into the corporate chain category, because if that were true, the size of the average affiliated independent store would have declined. In fact, it has steadily increased.

Considered as a whole, these market growth data underscore several important characteristics of this industry. First, total sales seem to grow at a fairly even pace. Second, the rate of market growth is large enough to accommodate different types and sizes of firms and stores, thereby implying fairly low entry barriers. Third, affiliation with a wholesalers group or operation of one's own wholesaling activity is a

<table>
<thead>
<tr>
<th>Year</th>
<th>Chain Sales Per Store</th>
<th>Chain %</th>
<th>Affiliated Sales Per Store</th>
<th>Affiliated %</th>
<th>Unaffiliated Sales Per Store</th>
<th>Unaffiliated %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>443,028</td>
<td>76.8</td>
<td>96,948</td>
<td>16.8</td>
<td>36,688</td>
<td>6.3</td>
</tr>
<tr>
<td>1948</td>
<td>425,775</td>
<td>77.2</td>
<td>88,652</td>
<td>16.0</td>
<td>36,697</td>
<td>6.6</td>
</tr>
<tr>
<td>1949</td>
<td>514,830</td>
<td>79.6</td>
<td>92,534</td>
<td>14.3</td>
<td>39,064</td>
<td>6.0</td>
</tr>
<tr>
<td>1950</td>
<td>529,957</td>
<td>79.0</td>
<td>97,986</td>
<td>14.6</td>
<td>42,737</td>
<td>6.3</td>
</tr>
<tr>
<td>1951</td>
<td>582,210</td>
<td>80.2</td>
<td>101,944</td>
<td>14.0</td>
<td>41,385</td>
<td>5.7</td>
</tr>
<tr>
<td>1952</td>
<td>629,184</td>
<td>79.1</td>
<td>118,105</td>
<td>14.8</td>
<td>47,843</td>
<td>6.0</td>
</tr>
<tr>
<td>1953</td>
<td>751,809</td>
<td>79.1</td>
<td>148,735</td>
<td>15.6</td>
<td>49,105</td>
<td>5.1</td>
</tr>
<tr>
<td>1954</td>
<td>848,744</td>
<td>79.7</td>
<td>163,209</td>
<td>15.3</td>
<td>52,011</td>
<td>4.8</td>
</tr>
<tr>
<td>1955</td>
<td>929,642</td>
<td>79.4</td>
<td>188,089</td>
<td>16.0</td>
<td>53,064</td>
<td>4.5</td>
</tr>
<tr>
<td>1956</td>
<td>1,074,830</td>
<td>77.9</td>
<td>255,864</td>
<td>18.5</td>
<td>48,641</td>
<td>3.5</td>
</tr>
<tr>
<td>1957</td>
<td>1,079,600</td>
<td>76.7</td>
<td>273,825</td>
<td>19.4</td>
<td>52,998</td>
<td>3.7</td>
</tr>
<tr>
<td>1958</td>
<td>1,041,610</td>
<td>76.6</td>
<td>266,031</td>
<td>19.5</td>
<td>51,975</td>
<td>3.8</td>
</tr>
<tr>
<td>1959</td>
<td>1,086,490</td>
<td>76.3</td>
<td>286,092</td>
<td>20.1</td>
<td>49,845</td>
<td>3.5</td>
</tr>
<tr>
<td>1960</td>
<td>1,107,190</td>
<td>73.8</td>
<td>343,355</td>
<td>22.8</td>
<td>49,132</td>
<td>3.2</td>
</tr>
<tr>
<td>1961</td>
<td>1,257,600</td>
<td>74.8</td>
<td>377,992</td>
<td>22.4</td>
<td>45,444</td>
<td>2.7</td>
</tr>
<tr>
<td>1962</td>
<td>1,260,590</td>
<td>73.7</td>
<td>404,664</td>
<td>23.6</td>
<td>44,758</td>
<td>2.6</td>
</tr>
<tr>
<td>1963</td>
<td>1,259,350</td>
<td>73.3</td>
<td>406,396</td>
<td>23.6</td>
<td>50,961</td>
<td>2.9</td>
</tr>
<tr>
<td>1964</td>
<td>1,277,100</td>
<td>72.6</td>
<td>430,131</td>
<td>24.4</td>
<td>50,846</td>
<td>2.8</td>
</tr>
<tr>
<td>1965</td>
<td>1,260,330</td>
<td>71.9</td>
<td>442,930</td>
<td>25.2</td>
<td>50,447</td>
<td>2.8</td>
</tr>
<tr>
<td>1966</td>
<td>1,174,340</td>
<td>71.1</td>
<td>428,608</td>
<td>25.9</td>
<td>46,592</td>
<td>2.8</td>
</tr>
<tr>
<td>1967</td>
<td>1,118,180</td>
<td>69.1</td>
<td>446,594</td>
<td>27.6</td>
<td>52,310</td>
<td>3.2</td>
</tr>
<tr>
<td>1968</td>
<td>1,155,920</td>
<td>70.8</td>
<td>422,177</td>
<td>25.8</td>
<td>54,324</td>
<td>3.3</td>
</tr>
<tr>
<td>1969</td>
<td>1,136,560</td>
<td>68.9</td>
<td>418,785</td>
<td>27.8</td>
<td>52,603</td>
<td>3.1</td>
</tr>
<tr>
<td>1970</td>
<td>1,069,440</td>
<td>69.9</td>
<td>493,476</td>
<td>30.6</td>
<td>57,268</td>
<td>3.5</td>
</tr>
<tr>
<td>1971</td>
<td>1,064,800</td>
<td>64.6</td>
<td>523,107</td>
<td>31.7</td>
<td>58,503</td>
<td>3.5</td>
</tr>
<tr>
<td>1972</td>
<td>1,035,500</td>
<td>62.8</td>
<td>550,853</td>
<td>33.4</td>
<td>61,258</td>
<td>3.7</td>
</tr>
</tbody>
</table>

necessity. In short, one gains a picture of a competitive industry in which the larger corporate chains enjoy some advantages but are constantly being tackled by the smaller, more flexible affiliated independents. These smaller rivals apparently find it relatively easy to grow and can either increase the size of existing stores or build new stores and graduate into the chain ranks.

**Distribution channels—vertical integration into wholesaling.**

Firms integrate from one level of an industry to another for several reasons. Vertical integration offers opportunities for cost reduction, for greater control over uncertain supplies, and for lessening the chances for foreclosure or price squeezes by powerful buyers of middlemen [22, p. 70]. Depending on the strength of these incentives in a given situation, vertical integration can have a broad range of effects on market concentration, minimum efficient size of firm, as well as pricing and performance within the industry.

The production and distribution of food includes five separate stages: 1.) agricultural production, 2.) manufacturing and processing, 3.) merchandising, including advertising and promotion, 4.) wholesaling, and 5.) retail distribution. While there are linkages by firms throughout the system some are more extensive and important than others. The focus is limited here to retailers integrated upstream into wholesaling.

Wholesalers as a group are primarily engaged in the function of distribution as opposed to basic manufacturing or selling at retail. The Census Department defines the wholesale trade to include establishments which sell merchandise to retailers, to industrial, commercial or
business users or to other wholesalers; they may also act as agents or brokers in buying for or selling merchandise to such persons or companies.

Clearly the most appropriate market in which to measure retail grocery seller concentration is no larger than the SMSA. However, the situation is somewhat different for grocery wholesaling, because the relevant sales market is probably larger than the SMSA but smaller than the nation.

The difference between retail and whole food distribution is somewhat like the difference between a car and a truck. On the one hand consumers are probably willing to travel only a few miles to do their supermarket shopping. On the other hand, economies of scale in wholesaling argue for centrally located warehouses that simultaneously service several retail markets. Given the geographic dispersion of retail markets and trucking and other transport costs, wholesalers decide on optimal locations for warehouses so that as many retail stores as is profitable can be serviced from one site.

A state or region is more likely to be the relevant market in which many grocery wholesalers compete. For example, in the New England region, containing 25 SMSA's, many of the large retail food chains, e.g., Finast, Stop & Shop, and A&P, have just 1, 2, or 3 centrally located warehouses to serve all of their stores. Thus defining the wholesale grocery market too broadly or narrowly may provide an inaccurate picture of the level of market concentration.

The number of general line, wholesale grocery establishments has increased slightly over the 1958-72 period. There were 2,818 establishments
in 1972. Constant dollar sales and sales per establishment have risen sharply, the former doubling and latter increasing by 60 percent over this same period. Tables 4.10-4.11 reveal these trends as well as detailing the breakdown in numbers and sales of voluntary group and cooperative wholesalers.\(^1\) Sales of the voluntary group wholesalers have been flat, while cooperative's sales have grown steadily. Sales of unaffiliated wholesalers have also been up sharply.

Table 4.12 provides data on national market share concentration for general line grocery wholesalers. Over 1954-72 all size categories have increased their respective shares but the levels are such that the national market must be considered as extremely unconcentrated by most standards. In 1972 the four firm concentration ratio was but 9.9 percent. Unfortunately concentration data for regional or state aggregations is difficult to obtain.

The NCFM noted that entry into food wholesaling is most often through retailing [\(^{114}\), p. 165]. However, even though there are clear cost savings to be gained many small, successful retail firms do not integrate backwards into wholesaling. This difficulty of entry at wholesale reflects the fact that the minimum optimal size of operation is probably much larger in relation to market demand in wholesaling as compared to retailing. Although there appears to be no systematic study of economies of scale in wholesaling, the comments of the NCFM are instructive,

\(^1\) Voluntary groups consist of five or more stores, individually owned, with the same tradename sponsored by a wholesale grocer and adhering to the wholesale supply and service program. Examples are IGA, Red and White, Super Valu, and Clover Farm. Cooperatives are composed of a group of retailers who are stockholders in a central buying and warehousing facility, who set up their own bylaws, and share in the corporation's profits. Examples include Certified Grocers and Associated Grocers.
Table 4.10. Number of Wholesale Establishments and Percent Change in Number for Selected Categories of General Line Grocery Wholesalers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Groceries, General Line, Total</td>
<td>2,253</td>
<td>2,530</td>
<td>2,543</td>
<td>2,812</td>
</tr>
<tr>
<td>Voluntary Group Wholesalers</td>
<td>673</td>
<td>708</td>
<td>734</td>
<td>396</td>
</tr>
<tr>
<td>Retailers Cooperative Wholesalers</td>
<td></td>
<td>161</td>
<td>173</td>
<td>225</td>
</tr>
<tr>
<td>Other General Line Wholesalers</td>
<td>1,580</td>
<td>1,661</td>
<td>1,636</td>
<td>2,197</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent Change in Number to 1972 from Indicated Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Groceries, General Line, Total</td>
</tr>
<tr>
<td>Voluntary Group Wholesalers</td>
</tr>
<tr>
<td>Retailers Cooperative Wholesalers</td>
</tr>
<tr>
<td>Other General Line Wholesalers</td>
</tr>
</tbody>
</table>

Source: Bureau of Census, Census of Wholesale Trade.

\(^a\) 1958 Census combines "voluntary and cooperative group grocery wholesalers."

\(^b\) Includes "cash and carry food depots" in this and subsequent years.
Table 4.11. Constant Dollar Sales (Mill. 1967 $) and Percent Change in Sales for Selected Categories of General Line Grocery Wholesalers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Groceries, General Line,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8,918</td>
<td>12,826</td>
<td>15,547</td>
<td>17,726</td>
</tr>
<tr>
<td>Voluntary Group</td>
<td>5,540</td>
<td>5,861</td>
<td>7,367</td>
<td>5,307</td>
</tr>
<tr>
<td>Wholesalers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail Cooperative</td>
<td>-</td>
<td>3,187</td>
<td>4,103</td>
<td>5,701</td>
</tr>
<tr>
<td>Wholesalers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other General Line</td>
<td>3,377</td>
<td>3,777</td>
<td>4,077</td>
<td>6,717</td>
</tr>
<tr>
<td>Wholesalers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Bureau of Census, Census of Wholesale Trade.

\[a\] 1958 Census combines "voluntary and cooperative group grocery wholesalers."

\[b\] Includes "cash and carry food depots" in this and subsequent years.

<table>
<thead>
<tr>
<th>Rank of Wholesalers</th>
<th>Percentage of wholesale sales accounted for in--</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st to 4th largest</td>
<td>7.4</td>
</tr>
<tr>
<td>5th to 8th</td>
<td>4.2</td>
</tr>
<tr>
<td>1st to 8th</td>
<td>11.6</td>
</tr>
<tr>
<td>9th to 20th</td>
<td>7.5</td>
</tr>
<tr>
<td>1st to 20th</td>
<td>19.1</td>
</tr>
<tr>
<td>21st to 50th</td>
<td>11.7</td>
</tr>
<tr>
<td>1st to 50th</td>
<td>30.8</td>
</tr>
</tbody>
</table>

Source: Data for 1954 through 1963 are from a special tabulation of the Bureau of Census as reported in National Commission on Food Retailing, Organization and Competition in Food Retailing, Technical Study No. 7, June 1966, p. 61.

Data for 1972 are from Bureau of Census, 1972 Census of Wholesale Trade, Establishment Size and Firm Size, Table 2c, p. 1-112.
Warehouse costs are reduced as volume increases up to an operation of $75 to $100 million annual retail sales. Some economies extend beyond this point.... In most cases, economies beyond $100 million annual retail sales would be so small they would not be a significant determinant of the firm's success. [14, p. 151]

If these estimates were to be updated to 1975 dollars, the cutoff level would be approximately $125-170 million rather than $75-100 million in annual retail sales. Given 1975 grocery store sales of $143 billion it is clear that the market could support a great number of warehouses and wholesalers on a national basis. However, it is in local and regional markets where the large chains would be most able to forestall the entry of smaller firms into the wholesaling segment of the industry. Without a complement of 25-50 stores, doing upwards of $2-3 million in annual sales per store, a small firm most likely lacks the volume to support a wholesaling operation. Whether or not this puts the small firm at a competitive disadvantage vis-a-vis the large chain is another matter, however, because cooperative, voluntary and unaffiliated wholesalers fill the gap.
Retail Seller Concentration and Geographic Compactedness

Two recent studies have suggested an interesting hypothesis about seller concentration in retail markets -- the size of a given retail market should strongly influence competitive conditions within the market. Thus by implication, large market areas in which there are numerous consumers should be less concentrated than smaller markets.

First, as a general matter with respect to all retail markets Porter [34] notes the following.

The limited geographic extent of the market and the magnitude of demand within this market area impose a strong constraint on the maximum number of retailers. The equivalent constraint on a national manufacturing industry is much weaker, so that the number of sellers in a retail market is typically smaller than that in even a "tight oligopoly" in manufacturing. (One direct implication of this is that retail competition is positively related to population density.)

Second, a staff report by the Council on Wage and Price Stability [6] observed the following about retail grocery markets, "[t]here is a tendency for concentration to increase as the market becomes smaller."

In order to test this hypothesis specifically in the context of local retail grocery markets, consider the model

\[ CR4 = f(POP, POPSQM) \]

where \( CR4 \) is the percentage of grocery store sales accounted for by the four largest grocery store companies in a given SMSA, \( POP \) is the population in an SMSA, and \( POPSQM \) is population per square mile of land area in an SMSA. The foregoing discussion implies that the independent variables should have a negative effect on concentration.
Data were collected on these measures for a sample of 50 of the 242 SMSA's in the U.S. SMSA's are assumed to approximate a local market area, although in the limit the relevant market may be smaller. Unfortunately the years of the Census of Business and Population Census do not coincide so CR4 is for 1967 whereas POP and POPSQM are for 1970, but it is doubtful that this discrepancy has much effect cross-sectionally. The data sources are listed below.

The correlation matrix for the 50 sample values was

<table>
<thead>
<tr>
<th></th>
<th>CR4</th>
<th>POP</th>
<th>POPSQM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR4</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POP</td>
<td>0.027</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>POPSQM</td>
<td>0.060</td>
<td>0.747</td>
<td>1.000</td>
</tr>
</tbody>
</table>

The ordinary least squares results from regressing the independent variables singly and then together on CR4 were (t-statistics in parentheses),

\[
\begin{align*}
\text{CR4} &= 51.238 + 0.251 \text{POP} \\
& \quad (28.416) (0.186) \\
R^2 &= 0.001 \\
F(1,48) &= 0.031 \\
\text{Std. error of regression} &= 10.556
\end{align*}
\]

\[
\begin{align*}
\text{CR4} &= 50.814 + 0.001 \text{POPSQM} \\
& \quad (24.230) (0.416) \\
R^2 &= .004 \\
F(1,48) &= 0.169 \\
\text{Std. error of regression} &= 10.541
\end{align*}
\]

\[
\begin{align*}
\text{CR4} &= 50.789 - 0.371 \text{POP} + 0.196 \text{POPSQM} \\
& \quad (23.921) (-.183) (0.410) \\
R^2 &= .004 \\
F(2,47) &= 0.099 \\
\text{Std. error of regression} &= 10.649
\end{align*}
\]

In all of the equations, the constant term is statistically significant from zero but the independent variables generally have the wrong sign and together the equations fail to explain more than a tiny fraction
of the variation in CR4. While these results do not necessarily "prove" a great deal, they indicate that the presumed relationship between concentration and the size of the market is not strong.

There is one technical caution that should be raised. CR4 probably depends on more than just the variables tested here; other determinants of CR4 might include measures of barriers to entry or product differentiation. The omission of these variables tends to yield biased and inconsistent parameter estimates, that is, the estimated coefficients and their standard errors are different from their "true" values. While there is undoubtedly some specification error in these equations, eliminating it would probably not change radically the results obtained for the measures of geographic compactedness.

More could be done with this analysis, but not very easily. For example, other determinants of concentration could be included. However, measures like the minimum efficient size (MES) divided by the relative size of the market involve a high degree of spurious correlation. This occurs because CR4 has the identical denominator, grocery sales in the local market. Other variables like product differentiation are hard to obtain and it would be nearly impossible to estimate how they varied over a cross-section of SMSA's.
### DATA

<table>
<thead>
<tr>
<th></th>
<th>Unweighted Means</th>
<th>Units</th>
<th>Standard Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR4</td>
<td>51.428*</td>
<td>percent</td>
<td>10.347</td>
</tr>
<tr>
<td>POP</td>
<td>755.960</td>
<td>thousands of persons</td>
<td>1116.08</td>
</tr>
<tr>
<td>POPSQM</td>
<td>467.860</td>
<td>persons per square mile</td>
<td>472.861</td>
</tr>
</tbody>
</table>

*Note: the sales-weighted mean CR4 equals 51.781.*

**Sources:**


Appendix 2

Calculation of the cost of inventory for a newly opened grocery store in 1974.

First, assume the following variables take their 1974 mean values:

1) S = average annual sales = $4,147,000, i.e. $79,750 weekly sales.
2) Square feet of selling area = 18487.
3) M/S = gross margin as percent of sales = 19.5%.
4) T = stock turns = 15.8.

Then to find the cost of inventory, I, we know that

\[
\text{Stockturns} = \frac{\text{Net cost of merchandise sold}}{\text{Average inventory at cost}}
\]

\[
T = \frac{C}{I}
\]  \hspace{1cm} (1)

and that,

\[
\text{Gross margin} = \text{Net sales} - \text{Net cost of merchandise sold}
\]

\[
M = S - C
\]  \hspace{1cm} (2)

Now, divide both sides of equation (2) by S to obtain

\[
\frac{M}{S} = 1 - \frac{C}{S}
\]

\[
.195 = 1 - \frac{C}{4,147,000}
\]

\[
C = .805 (4,147,000) = 3,338,000
\]

Then substitute value for C into equation (1),
\[
\begin{align*}
T &= 3,338,000 / I \\
15.8 &= 3,338,000 / I \\
I &= $211,287
\end{align*}
\]

Therefore, the total capital requirement is:

- **Capital investment** $655,050.
- **Opening inventory investment** $211,287.
- **Total investment per store** 866,337.

Sources: Sales, S, and store size are from Super Market Institute, *Facts about new supermarkets opened in 1974*; gross margin over sales, M/S, and stockturns, T, are from W. Earle and W. Hunt, *Operating Results of Food Chains, 1974-75*, Cornell University.
References


4. (intentionally blank).


Chapter 5. An Econometric Model of the Supply and Demand for Cattle and Beef.

Introduction.

This chapter builds upon the discussion of actual market structures in the previous three chapters in order to develop a theoretical specification of the process of beef price determination. While the approach taken here is conventional in many respects there are some shortcomings in the general literature which are redressed. The leading motif in what follows is that the three principal beef markets—farm, slaughter, and retail—are important both in isolation and as they relate to each other. These markets are dynamic and continually in a process of adjustment as new information becomes available. Price and quantities are determined simultaneously in each market by the intersection of supply and demand for that respective market. No econometric model can fully capture the myriad complexities involved in such a large and diverse set of markets. What is intended, however, is that the major economic forces which do determine equilibrium prices and outputs can be described.

In past analyses, it has too often been the case that just a single element or perhaps two in the causal structure has been seized upon as the critical determinant of price. For example, Waugh, a widely respected agricultural economist, notes that:

There are two conflicting notions concerning the relationship between demands at farm and retail levels. Some people are firmly convinced
that food prices are made at the farm—and that retail prices are made up of the farm price plus various charges for processing and distribution. In the short run, this may often be true....

But in the long run, I think that consumer demand is controlling. It is based upon the wants and preferences of consumers, together with income, prices, and supplies of competing commodities and other factors. This being true, in the long run, food prices are determined at the retail market by what the consumer can and will pay for what is offered. [61, pp. 19-20]

This point of view is still widely held today.¹

The current method takes the broader view that supply is also an important matter, but more importantly that it is the simultaneous interaction of supply and demand in each separate market which determines price. Although the three markets are closely tied together they are separate enough to be considered as independent centers of economic decision-making. No single element in the chain is all-controlling. Also a richer theory is applied to the problem of marketing margin behavior.

The sections of this chapter are organized as follows. First, a critical review of the existing agricultural econometric literature is provided. Then the theory supporting an alternative econometric model is developed. Separate equations are specified for the major determinants of beef price at each market level. A section on price spreads indicates their importance in the overall framework. The appropriate techniques for estimating the econometric model are discussed in a final section.

¹See for example Heien [21, p. 127].

Beef is probably the most widely studied of agricultural commodities. Just since 1960 there has been a large number of investigations on the following topics:

a) comprehensive empirical and theoretical food models
b) livestock models
c) beef and pork models
d) pork (exclusively) and poultry models, and
e) marketing margins

This section provides a review of this literature, but limits the perspective to work appearing after 1960.

Introduction and Overview of the Literature.

Tomek and Robinson [53] in a recent publication offer the most comprehensive review to-date of the literature on agricultural price analysis. Their purpose is to document those important theoretical and empirical studies dealing with agricultural product and input prices over time, space, form or quality, and market levels. A companion piece by French [11] reviews a large number of studies of productive efficiency in the field of agricultural market analysis. Both pieces are highly useful introductions to the literature of agricultural economics. Also, King [30] provides a short guide to most extant econometric models of the agricultural sector.
Comprehensive Empirical and Theoretical Food Models.

Brandow [4] offers a complete system of demand own-price, cross-price, and income elasticities for twenty-four distinct food items. The intended purpose of the model is to analyze the demand for farm products and the possibilities for increasing farm prices and farmers' cash receipts through the control of supply. The model is constructed by applying the elasticity estimates obtained from a number of other studies and then invoking several theoretical restrictions on the demand coefficients. Results are obtained for beef demand at both the retail and farm level. It is found that direct price elasticities are lower in absolute value at the farm level than at retail. Cross-elasticities are also lower at the farm. The relative differences in elasticities between the two levels are greater the larger the marketing margin.

George and King [14] present an analysis of the retail and farm demand for forty-nine food commodities in the U.S. for the post World War II period using both time-series and cross-section data. The approach which is similar to Brandow's [4] takes account of the completely interdependent nature of demand. Analysis of price spreads shows that for most commodities, marketing margins are a linear function of retail prices. For beef the farm-retail price spread is neither a constant percentage nor constant absolute amount, but somewhere in between the two.

Additional theoretical models of the agricultural sector include Nerlove's classic [43] in which he develops the concept of adaptive expectations as applied to the process of farmer decision making. Myers

Livestock Models.

Freebairn and Rausser [10] specify a simultaneous equation model of the behavior of the fed beef (meat from feedlot cattle), other beef (from cull cows, range-fed cattle, and imported beef), hog, and poultry sectors. The dairy, grain and livestock feed, and other sectors are assumed predetermined. Consumer demand equations describe behavior at the retail level. Margin equations link retail and farm prices. (These are discussed in more detail below). Other equations describe production, inventory, net trade, and stock changes. Fed beef is found to be a superior good whereas other beef is an inferior good. The supply of both fed beef and other beef was found to be highly inelastic. The model is used to evaluate the effect of increases in beef imports on the livestock sector. Larger beef imports reduce the retail price of all meats with the lower quality meats the most affected. At the farm level increased imports reduce the prices of slaughter steers, cull cows, and feeder calves.

Heien, Kite, and Matthews [23] in an unpublished paper describe a large-scale model of the U.S. livestock economy. In twenty-seven
stochastic equations and nine identities the authors deal with the following livestock sectors: beef, pork, broilers, turkey, other chicken, eggs and dairy products. The demand side is modelled at retail and farm levels by price dependent relations. The supply of beef is specified in terms of separate equations for a) the change in beef cow inventory, b) beef heifer additions, c) beef cow slaughter, d) beef heifer and steer slaughter, e) dairy cow slaughter, f) calf slaughter, and total production of g) fed beef, h) non-fed beef, and i) veal. This is perhaps the most detailed specification of the beef economy that exists in the literature. The model is estimated by ordinary least squares with annual data covering 1950-1970.

A particularly interesting part of the Heien, et al. study is an analysis of the effect of increases in money income. They find that for a given change in income, increases in price for all types of livestock are large. They obtain a beef price-income elasticity of 1.33 in the first year, but the corresponding increases in supplies and slaughter numbers are relatively small. This result corresponds with the intuition of many analysts who have claimed that the supply functions for livestock are fairly inelastic. Thus, rightward shifts in demand would induce strong price increases in the short-run. Heien, et al. also find that in the long-run when increased supplies come forth in response to the high initial prices, all prices fall rapidly especially beef prices. They estimate a long-run elasticity of retail beef price with respect to income of .32.

Hassan and Katz [17] analyze the demand for the major livestock
products using Canadian data. Tryfos [54] studies both supply and demand for livestock commodities, also in a Canadian context.

**Beef and Pork Models.**

Reutlinger [47] presents a fairly detailed theoretical specification of separate supply functions for steer, cow, and heifer slaughter. The model takes account of derived inventory demand, as well as the fact that cow and heifer supply depends critically on price expectations in that they can either be slaughtered for current consumption or retained as an investment to build up inventories. The short-run supply curve for all beef is found to be highly inelastic and possibly even backward bending. The individual results for steers and cows seem more plausible and reliable than for heifers.

Langemeier and Thompson [34] employ a twelve equation model of both supply and demand including seven simultaneous equations. The effects of weather are introduced by a range conditions variable. One finding is that there is a highly inelastic supply function for all beef. However, there is no distinction drawn between the short- and long-run. Another interesting result is that fed and nonfed beef are strong substitutes on the demand side, and that nonfed beef is an inferior good. Also there is an application of the model to the early 1960's in order to explain reasons for sagging beef prices. The final explanation was not an increased level of imports as had been thought, but rather that

1. imports and fed beef supply had opposite effects on fed beef prices,
2. variations in fed beef prices resulted primarily from changes in the supply of fed beef and in disposable income. Thus sagging beef prices in/early 1960's were the result of substantial increases in an extremely inelastic supply function coupled with fairly small increases in a demand function of near unit elasticity.

Kulshreshtha and Wilson [32] provide a simultaneous equation model of the supply, demand, export, and inventory aspects of the Canadian beef market. The model covers the period 1949-69. Two stage least squares is used. The results on the supply side show a minimal response in cattle feeding to changes in the farm price level relative to feed grain prices. Also, grain prices had a negative yet minimal effect on inventory. The model is used to produce a forecast for 1975. Indication is that beef production can be increased in the short-run through a high beef feed index. However, in long-run increased output of beef depends on an abundant supply of feed grains.

Jarvis [27, 28] offers a refreshingly different approach to modelling the cattle sector. Cattle are assumed to be capital goods, either growing machines or "mother" machines, which producers hold as long as their capital value in production exceeds their slaughter (i.e., salvage) value. In effect, ranchers can be viewed as portfolio managers who seek the optimal combination of different types (i.e. age and sex) of animals to complement their non-cattle assets. Jarvis adds a new wrinkle in the way in which he deals with the possibility that short-run supply response may be negative. He points out that because cattle production can only be increased by increasing the size of the breeding herd and/or withholding animals from further fattening, producers must
bid away animals from consumers to increase their capital stock which is the source of higher future beef production. This phenomenon coupled with the lengthy gestation period for cows causes the negative supply response to persist for some time. A rigorous theoretical micro-model is developed to explain optimal slaughter behavior on the part of producers. Econometric results are obtained which support the view that supply response is radically different in the short- vs. the long-run.

Other notable econometric beef and pork models include Fuller and Ladd [12] who adopt an approach similar to that of Heien, Kite, and Matthews [23] (see discussion above), and Kulshreshtha [32] who uses a polynomial distributed lag model to estimate long and short-run supply response in the Canadian beef market. Also there are sectoral models of the pork and poultry economies. [18,19,40].

Theory and Practice in the Study of Price Spreads.

Gardner [13] presents a theoretical model of the marketing margin in a competitive industry. He derives results for the effect that various shifts in the demand for and supply of food will have on margins. He shows that in order to be compatible with market equilibrium the markup must change whenever demand or supply shifts. This implies that no simple markup pricing rule -- a fixed percentage margin, a fixed absolute margin, or a combination of the two -- can in general accurately explain the relationship between farm and retail
112

price. This is so because these prices move together in different ways depending on the source of their movement, i.e. a shift in retail demand, farm supply or marketing inputs.

Griffith [15] analyzes Australian wholesale and retail meat marketing margins in a simultaneous equation format. Farm-to-wholesale margins are specified as a function of current and lagged farm prices, wholesale costs, and turnover (a volume measure). Wholesale-to-retail margins are similarly a function of current and lagged wholesale prices, retail costs, and turnover. Results obtained from monthly data for 1971 to mid-1974 indicate that both wholesale and retail margins are negatively related to current input prices but positively related to past prices. Griffith suggests this as proof of price leveling, i.e. the practice of wholesalers (retailers) holding their selling prices stable in the face of rising or falling auction (wholesale) prices. It was also found that costs positively affect margins, whereas turnover has a negative effect but only in the wholesale margin equation. A defense of price leveling in the short-run is offered on the grounds that it a) tends to reduce uncertainty, b) is often preferred by consumers, and c) saves costs involved in frequently changing prices. In the long-run price leveling could distort resource allocation.

Heien [20] in a study prepared for the Council on Wage and Price Stability analyzes the question of how quickly retail (wholesale) food

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1 This is an important point that will be more fully developed in a later section dealing with the theory of beef marketing margin functions.
prices respond to changes in wholesale (farm) prices. The underlying structural model is the Eckstein-Fromm price equation which relates changes in the price of a good a) to changes in the costs of producing the good, e.g., wages, materials, etc., and b) to factors affecting profits, e.g., demand pressure variables. Heien only relates prices to costs. At the retail level price is a function of wholesale price and the wage rate in retail food stores. Wholesale prices are specified as a function of farm value and an index of transportation, labor, packaging and energy costs. Heien estimates these price functions as a distributed lag in order to capture the dynamic properties of the process. Results obtained from a sample of monthly data for 1960-75 show that retail beef prices are a strong positive function of retail wages and wholesale beef prices. Wholesale prices were found to only be a function of farm prices. It was concluded that increases in farm level prices are passed on to the retail level rapidly; 50% of the increase is passed on in 2 months for livestock products. The total impact of changes in farm prices depends on the proportion of farm value to retail price. A separate econometric test showed little evidence of asymmetric price changes, i.e., positive or negative price changes were just as likely to be passed along the marketing chain from the farm to retail level.

Fuller and Ladd [12] analyze the beef and pork sectors with special emphasis on marketing margin behavior. Their wholesale-to-retail margin for beef is specified as a function of retail wages, the lagged margin, and wholesale beef and pork prices. The margin is taken
to represent the price of retailers services. The results show that retail prices lag in their response to changes in wholesale prices. Also, wages are a significant positive explanation of margins. The analysis of the farm-to-wholesale margin considers the point that changing the level of operation may be important in meat packing.

Freebairn and Rausser [10] as part of a larger livestock sector model (noted above) examine farm-retail marketing margins for fed and other beef. The specification includes wages as a determinant of margins and allows for both a percentage and absolute margin while trying to capture the effect of price leveling marketing practices which stabilize retail price fluctuations relative to farm prices. Results for the period 1956-71 show a strong positive relationship between fed and other beef margins and both farm prices and wage rates whereas changes in farm prices are negatively related to margins.

Waldorf [59] presents a unique approach to the analysis of marketing margins by estimating the demand for and supply of food processing and distribution services. The purpose is to explain the decline in the farmers' share of U.S. consumer food expenditures. In estimating the demand for marketing services function Waldorf finds a price elasticity of -.76 and an income elasticity of .70. On the supply side the results are less reliable, but the function is believed to be fairly price elastic. Given the large post-war surge in the demand for services, the elastic supply curve kept pace with the result that the real price of services was relatively flat. The explanation for the 25% decline in the farm share of consumer expenditures on food from
1947-62 is in two parts: a) about one-third was due to the greater relative increase in the demand for services compared to farm products, and b) about two thirds was due to the greater increase in the supply of (relative to the demand for) farm products.

Other models which also include an analysis of beef margin behavior are George and King [14] (see above), Langemeier and Thompson [34] (also see discussion above), and Barr and Gale [3]. Also the Council on Wage and Price Stability released a staff report [57] that is largely based on the work of Heien [20], (discussed above). King [20] analyzes the question of the speed of price transmission between different market levels for beef products. Crom and Duewer [8] simulate price trends under both fixed absolute and percentage margins.

Summary and Critique of Key Findings.

The preceding sections are a review of the major recent work in the field of beef price and margin modeling. At the risk of oversimplification the following summary and critique is offered of the key findings.

First, most models deal with a single commodity and have a fairly typical structure. At the farm level only supply-related variables are treated. In addition to production (or slaughter), there may or may not be a separate equation for inventory. At the retail level, consumer demand is the sole focus. Then farm supply and retail demand may be linked via a margin equation which has separate conceptual difficulties associated with it. The problem with this type of structure is that it
completely omits (or at best only indirectly treats) the role that the packing and retailing industries have in price determination. This model structure implicitly assumes that the farmer and consumer are the forces which primarily determine output and price.

As was alluded to in the introduction to this chapter the model developed here is designed to shift the focus somewhat in order to examine all the major factors which influence the price and quantity of beef. The essential point is to show that beef prices are determined simultaneously in three separate markets -- farm, slaughter, and retail. This specification follows from the discussion of the structure of each of these markets provided in the earlier chapters. Thus, importance is given to each major area in which production and consumption decisions interact to yield observable market prices. This idea of a three-tiered industry involving simultaneous price determination in each market has not received adequate attention in either the theoretical or empirical literature.

A second problem with the empirical studies found in the literature is that there is very little theory of margin behavior that has been used to develop the variety of estimates. Typically an ad hoc model is developed in which the margin is specified as a function of input price. For example, the farm-retail margin is often specified as a markup over farm price. While such equations often yield good fits in terms of high $R^2$'s there is little economic content to such a specification. The model derived in the sections that follow attempts to provide a sound theoretical explanation of the behavior of marketing
margins by explicitly examining the economic forces which determine them.

A third major problem area in the literature is that too often simultaneous equations methods are not used to estimate agricultural econometric models. This is especially true of many retail beef demand equations for which an elaborate defense has been constructed of single equation methods. Proponents of this approach argue that for agricultural commodities, supply is fixed in the short-run and therefore predetermined, so that the only variation which can occur is in the price axis. Accepting this view, price is specified as the dependent variable in the demand equation, and then although a contemporaneous quantity variable appears on the right-hand side of the regression it is by construction a predetermined variable and not simultaneously determined with price. Given these assumptions no simultaneity bias is present, and single equation methods of estimation are appropriate, ceteris paribus. Unfortunately, this specification is not valid for livestock products because supply is not fixed in the short-run. Producers can adjust dynamically to changing expectations. As Jarvis observes,

Although the profit expected by a producer at the time he initiates a cattle enterprise depends on holding the animals to a particular age and physical condition, he may choose to sell the animals at any time before or after his original target marketing date if conditions change -- or he may choose to increase his herd if he so desires. This cannot be done in most agricultural enterprises [27, p. 106 ff.]

The model outlined below attempts to deal with these dynamic properties by allowing for greater simultaneity in the specification (and therefore
using simultaneous equations estimation techniques) and also by recognizing the importance of time (i.e., short vs. long-run) in supply response.

A summary is provided in Table 5.1 of many of the key econometric results obtained for beef models over the past fifteen years.\footnote{1} Several points are to be noted from the Table:

1. supply is fairly price inelastic for beef,
2. nonfed beef is an inferior good, and
3. demand is more price inelastic at the farm level than at the retail level.

While it certainly is an important matter little attention is given to short-run vs. long-run elasticities.

\textbf{Specification of Econometric Model \textendash\ General Principles.}

Specifying the demand and supply functions for beef cannot be done by brute-force application of standard formulae; rather the particular aspects of demand and supply in each market must be explicitly accounted for in the econometric analysis. Yet, certain common principles were applied to the formulation of each equation so to avoid repetition these areas of commonality will be discussed first.

The primary purpose of this model is to evaluate several hypotheses regarding the markets in which beef is bought and sold. This end is in contrast to that of some other econometric models whose sole

\footnote{1}{In the following chapter where some new results are presented, it will be useful to refer back to the estimates in Table 5.1 which are representative of the literature.}
Table 5.1 Summary of Quantitative Results from Econometric Beef Models

<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Brandow [4]</td>
<td>Cattle-Beef</td>
<td>-.95\textsuperscript{a} ,-.68\textsuperscript{b}</td>
<td>-.2c ,-.83</td>
<td>.47\textsuperscript{a}</td>
<td>3SLS (1955-'57)</td>
</tr>
<tr>
<td></td>
<td>Calves-Veal</td>
<td>-1.60\textsuperscript{a} ,-1.08\textsuperscript{b}</td>
<td>-.43</td>
<td>.56\textsuperscript{a}</td>
<td></td>
</tr>
<tr>
<td>Freebairn and Rauser [10]</td>
<td>Fed Beef</td>
<td>.2\textsuperscript{c}</td>
<td>-.83</td>
<td>1.61</td>
<td>OLS</td>
</tr>
<tr>
<td></td>
<td>Other Beef</td>
<td>\textsuperscript{1}</td>
<td>-.43</td>
<td>-.21</td>
<td></td>
</tr>
<tr>
<td>George and King [14]</td>
<td>Beef</td>
<td>\textsuperscript{1} ,-.64\textsuperscript{a} ,-.4\textsuperscript{b}</td>
<td>\textsuperscript{1} ,-1.72\textsuperscript{a}</td>
<td>.29</td>
<td>OLS (1946-'65)</td>
</tr>
<tr>
<td></td>
<td>Veal</td>
<td>\textsuperscript{1}</td>
<td>-.77</td>
<td>.55</td>
<td>FIML (1957-'72)</td>
</tr>
<tr>
<td>Hassan and Katz [17]</td>
<td>Beef</td>
<td>\textsuperscript{1} ,-.77</td>
<td>\textsuperscript{1}</td>
<td>.55</td>
<td>FIML (1957-'72)</td>
</tr>
<tr>
<td></td>
<td>Veal</td>
<td>\textsuperscript{1} ,-3.02</td>
<td>\textsuperscript{1}</td>
<td>1.73</td>
<td></td>
</tr>
<tr>
<td>Heien, Kite and Matthews [23]</td>
<td>Fed Beef (heifers and steers)</td>
<td>.32</td>
<td>-.80\textsuperscript{a} ,-.307\textsuperscript{b}</td>
<td>1.044</td>
<td>2SLS (1949-'69)</td>
</tr>
<tr>
<td></td>
<td>Dairy cows</td>
<td>.55</td>
<td>\textsuperscript{1}</td>
<td>.55</td>
<td></td>
</tr>
<tr>
<td>Kulshreshtha and Wilson [33]</td>
<td>All Beef</td>
<td>-.098 to .215</td>
<td>-.801\textsuperscript{a} ,-.307\textsuperscript{b}</td>
<td>1.044</td>
<td>2SLS (1949-'69)</td>
</tr>
<tr>
<td>Kulshreshtha [32]</td>
<td>Beef</td>
<td>\textsuperscript{1} ,.09\textsuperscript{e} ,1.00\textsuperscript{f}</td>
<td>\textsuperscript{1}</td>
<td>\textsuperscript{1}</td>
<td></td>
</tr>
<tr>
<td>Langemeier and Thompson [34]</td>
<td>All Beef</td>
<td>\textsuperscript{1} ,.16\textsuperscript{b}</td>
<td>\textsuperscript{1} ,-1.06\textsuperscript{a}</td>
<td>\textsuperscript{1}</td>
<td>2SLS (1947-'63)</td>
</tr>
<tr>
<td></td>
<td>Fed Beef</td>
<td>\textsuperscript{1} ,.232 ,-.978\textsuperscript{a} ,-.893\textsuperscript{b}</td>
<td>2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonfed Beef</td>
<td>\textsuperscript{1} ,-.552 ,-1.263\textsuperscript{a} ,-1.011\textsuperscript{b}</td>
<td>\textsuperscript{1}</td>
<td>-1.312</td>
<td></td>
</tr>
<tr>
<td>Author</td>
<td>Commodity</td>
<td>Supply Price Elasticity</td>
<td>Demand Price Elasticity</td>
<td>Income Elasticity</td>
<td>Estimation Method*</td>
</tr>
<tr>
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</tr>
<tr>
<td>Reutlinger [47]</td>
<td>All Beef</td>
<td>-.034</td>
<td>.162 to .176</td>
<td>Steers</td>
<td>(1947-'62)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cows</td>
<td>-1.225 to -.924</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Heifers</td>
<td>.631 to -.686</td>
</tr>
<tr>
<td>Tryfos [54]</td>
<td>All Beef</td>
<td>-.009 to .004d</td>
<td></td>
<td></td>
<td>3SLS (1951-'71)</td>
</tr>
</tbody>
</table>

*Estimation Methods:
- OLS: Ordinary Least Squares.
- 2SLS: 2 Stage Least Squares.
- 3SLS: 3 Stage Least Squares.
- FIML: Full information maximum likelihood.
- PDL: Polynomial Distributed Lag.

\(^a\) Retail.
\(^b\) Farm.
\(^c\) At current prices.
\(^d\) At expected prices.
\(^e\) Short-run
\(^f\) Long-run
purpose is to provide conditional forecasts of future beef supplies and prices based on assumed values of the exogenous variables. One hypothesis to be tested is whether the elasticities of supply and demand at the three market levels are different. It has been claimed that farm level relations on both the demand and supply sides are much more inelastic than their respective packer and retail relations. Yet, there exists little by way of empirical verification of this idea. The results are important for market performance in the beef industry for a number of reasons. Relatively steeper (or less elastic) farm level functions would explain why farm prices and income are much more volatile than similar packer or retail variables. Also the relative slopes of the demand and supply functions determine the size of price spreads for beef and thus have far-reaching implications for firms which both produce and market beef. (This point is developed more fully in a following section on marketing margin functions.) Possible attempts at market control can also be tested by use of the econometric model. This idea is examined in the final chapter.

**Demand for Beef**

The approach taken on the demand side in each market is to model the behavior of individual economic agents, i.e., demands at the farm are from slaughterers, at wholesale from retailers, and at retail from the ultimate consumers of beef products.

Consumers are assumed to maximize their utility subject to a budget constraint. This maximization process yields the individual
consumer's demand relation for beef which can be written as

\[ Q_{B,t} = f(P_{B,t}, P_{0,t}, Y_t, u_t) \]  

Equation (5.1) states that an individual's consumption of beef in year \( t \) \( (Q_{B,t}) \) is a function of the price of beef in year \( t \) \( (P_{B,t}) \), a vector of prices of other products which are beef substitutes \( (P_{0,t}) \), a vector of economic activity variables, like personal disposable income, in year \( t \) \( (Y_t) \), and a random error term \( (u_t) \) which represents effects not adequately measured by the other variables.

If equation (5.1) represents the individual's demand for beef then the aggregate demand for beef, \( QD_B \), is simply the horizontal summation of the quantities demanded by all consumers at a given price.\(^2\) In order

\(^1\) Throughout the analysis, variables will be expressed in the general form: \( X_{i,j,t} \) where \( i \) indexes products as in

\[ i = \begin{cases} 
B & \text{beef products}, \\
C & \text{chicken}, \\
P & \text{pork}, \\
0 & \text{other};
\end{cases} \]

and \( j \) indexes market levels as in

\[ j = \begin{cases} 
F & \text{farm level}, \\
S & \text{slaughter level}, \\
R & \text{retail level};
\end{cases} \]

and \( t \) indexes time. In the next few sections the time subscript will be dropped for simplicity.

\(^2\) The issue of aggregation is examined in the following section.
to control for secular increases in population, the common practice will be followed of expressing QDB in per capita terms. This means that income, Y, should also be expressed on a per capita basis.

There are several issues to consider when actually implementing this specification. First, an explicit functional form must be chosen. Recent evidence suggests that of the two major alternatives, linear or log-linear, the latter is to be preferred, although both involve certain restrictive assumptions [7a]. The aggregate form of equation (5.1) written in linear form,

$$QDB = a + bP_B + cP_O + dY + u$$

(5.2)

assumes that all of the effects on consumption are additive, so that a given absolute change in one of the independent variables has the same absolute effect on consumption for all values of that exogenous variable.

As an example of the rigid assumptions implicit in equation (5.2) consider the coefficient d on the income term. It is well known, by Engel's Law or otherwise, that the income elasticity for beef should decline over time as consumer incomes rise because the commodity becomes less of a luxury and more of a necessity. Yet, the linear form of the demand function imposes the assumption that the income elasticity is rising and that it tends toward one if income inelastic.

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1 A more general specification for the demand for meat has been tested by Chang [7a]. Unfortunately, the inherent nonlinearities involved in this alternative precluded extensive testing.
Alternately, the log-linear form assumes that the determinants of QD enter the equation multiplicatively as in

\[ QD_B = A_P B_P C_Y d \]

so that a given percentage change in one of the right-hand side variables has a constant percentage effect on consumption. One advantage of this specification is that it avoids the absurd result of negative consumption sometimes obtained in linear relations for very high values of own-price and low values of income. Also elasticities are conveniently read off as the estimated coefficients upon taking logs of both sides to obtain

\[ \log QD_B = \log A + b \log P_B + c \log P_0 + d \log Y + \log u \]  

However, consider again the restrictions imposed upon the coefficient d in equation (5.4). In this case the income elasticity is assumed to be constant over the entire span of the demand function. Although both forms have their drawbacks, the double log form seems less restrictive and more convenient. For these reasons, the results in the following chapter will be for the logarithmic formulation.

Another concern related to the variables entering the demand function is that of deflation. Prices and income are expected to affect consumer utility only in real terms. Thus in each market, a deflator must be selected which reflects movement in the general price level so that all nominal effects can be purged from the model. In choosing the best deflator for a given circumstance Shepherd provides guidance,
One of the simplest ways to hold the demand curve still is to divide the price series by some measure of the forces that shift it about. Thus if general inflation has doubled the general level of prices, including the price of the good in question, then dividing the prices of the good by the corresponding index of the general price level each year will in effect hold the demand curve still.... But this process is effective and accurate only if the relation between the price of the good and the deflator is 1 to 1. In actual life, this may not be true. [50, p. 127]

Accordingly, prices at each market level have been deflated by the most appropriate wholesale and consumer price indexes available. Also, all other variables in nominal terms, e.g., income and wages, are deflated by the appropriate price indexes.

A final problem with the general specification of the demand function is the form in which the substitute prices are to enter the equation. The major substitutes for beef are pork and chicken, but their prices are highly collinear so in a regression it would be difficult to identify their separate effects. Accordingly, a weighted average of pork and chicken prices is employed to capture the effect that these substitutes in common have on the demand for beef.

Supply of Beef.

On the supply side, a key issue is the shifting temporal aspect of the production process in each market. A farmer makes an investment in an animal when it is bred, but then must wait as long as two or three years to realize a return on this investment depending on how he decides to feed and market the animal. Contrariwise a packer can pur-
chase slaughter cattle from a feedlot and have the animal slaughtered, processed, and the dressed carcass sold within a matter of days. For the retailer, who is dealing in an extremely perishable commodity by the time the carcass or cuts reach him, the length of the production run is even shorter than for the packer. The great disparity in the relative length of time required to produce cattle versus beef has much to do with the risks to which cattlemen are exposes vis a vis packers or retailers.

As a general matter the supply functions for each market are derived from the standard theory of the firm under conditions of pure competition. Suppose production for a given firm can be described by a Cobb-Douglas production function

$$Q = dL^a K^b M^c$$

(5.5)

where $Q$ is output, $L$, $K$, and $M$ represent physical quantities of labor, capital, and materials inputs respectively and $a$, $b$, $c$, and $d$ are parameters.

The cost function associated with this production function can be obtained by solving the cost minimization problem

$$\min Z = wL + rK + vM$$

(5.6)

subject to $dL^a K^b M^c = Q$

where $w$, $r$, and $v$ are the respective factor prices for $L$, $K$, and $M$. The first order conditions for a minimum of $Z$ are then used to obtain the cost function which expresses total cost, $C$, in terms of the level
of output and the factor prices

\[
\frac{1}{s} a/s b/s c/s \\
C = D Q w r v
\]

(5.7)

where D is a constant that depends on a, b, and c, and \( s = a + b + c \).

Finally, the supply function is found by differentiating \( C \) with respect to \( Q \) and setting the result equal to the price of output, \( P \), since under competitive conditions price equals marginal cost,

\[
\frac{\partial C}{\partial Q} = \frac{1}{s} D Q \frac{(1-s)}{s} a/s b/s c/s = P
\]

(5.8)

rearranging terms yields

\[
Q = (sD-Pw-a/sr-b/sv-c/s)s/(1-s)
\]

(5.9)

Equation (5.9) represents the supply function for an individual firm. This corresponds to that portion of the firm's marginal cost curve which lies above its average cost curve. The aggregate beef supply function, \( Q_{SB} \), for the entire market level is just the horizontal summation of all of these individual supply functions.

The aggregate form of equation (5.9) with an additive error term would not be easy to estimate econometrically because it is nonlinear in the parameters, but taking logs of both sides (assuming a multiplicative error term) and simplifying yields a more tractable equation which is linear in the parameters,

\[
\log Q_{SB} = D' + g' \log P + a' \log w + b' \log r + c' \log v
\]

(5.10)

where \( D' = (s/(1-s)) \log (s/D) \); \( g' = s/(1-s) \); \( a' = s'^2 + as-a \); \( b' = s'^2 + bs-b \); and \( c' = s'^2 + cs-c \). When actually estimating the supply
functions for each market it is also necessary to include an error term for those unobserved or unmeasured factors which are here assumed to enter equation (5.10) additively. Unfortunately, suitable data do not exist for all of the variables in equation (5.10), especially the cost of capital, \( r \). However, this should not pose a great problem at least for the slaughter and retail industries because capital costs are a small fraction of total costs.\(^1\)

It should also be noted at this point that all of the functions derived in this chapter for econometric estimation are obtained by aggregation over firms or individuals. For example, the basic supply relationship given in equation (5.10) is an aggregation over an entire industry of the individual firm's supply function. Similarly for demand, equations (5.2) and (5.4) were derived by summing over all individuals. In principle these types of linear aggregations can lead to certain statistical problems. What one is trying to accomplish by aggregation is to obviate the need for dealing with microrelations, say for separate individuals or firms, by building up to a macrorelation from the separate components. Furthermore, as a practical matter most available economic data is aggregative, including that available for the current analysis. The problem is that the parameters of the macrorelation are subject to aggregation bias, where the degree of bias depends on the covariance between the individual micro-parameters [60, p. 11]. It is difficult to quantify the extent to

\(^1\) See sections of Chapters 3 and 4 dealing with capital requirements. An earlier econometric study of cattle supply response by Jarvis [27] found that an interest rate variable although useful in theory was of little practical significance.
which the parameters derived below will be biased by aggregation. There is good reason to believe that any aggregation errors will not be severe because this study is confined to fairly homogeneous industries (farm, slaughter, and retail) and to a single commodity (beef).

Equilibration Process.

The analysis presented here is based on the assumption that each market level is purely competitive. Therefore the conditions which must hold in each market are that: 1) firms produce a homogeneous commodity, and consumers are identical from the sellers point of view, 2) there are a large number of both buyers and sellers with no effective concentration in the hands of a few, 3) buyers and sellers possess perfect information about prices and costs and seize any opportunity to increase utility or profits, and 4) there are no barriers to entry or exit for either buyers or sellers.

Given these conditions and the existence of market supply and demand functions, the determination of price in each market is found by equating supply and demand so as to clear each market. Once the equilibrium price is found, equilibrium quantity can be determined by inserting price in either the supply or demand function. So far the process is fairly simple, and perhaps unrealistic. Yet, it is assumed for purposes of analysis that beef markets to a first approximation conform to the idealized model of pure competition. This assumption is made knowing full well that from time to time some of the perfect market assumptions may be violated. Also, in actual beef commodity
markets one rarely if ever observes such a thing as an equilibrium price or quantity because the underlying schedules of supply and demand are continually shifting as consumers and producers maximize utility and profit in response to ever changing conditions. For the purposes of specifying this econometric model, no qualitative distinction is drawn between a market which is in a continuous process of adjusting towards equilibrium and one which is actually in equilibrium.

The stability of any given equilibrium is also a matter of importance in beef markets, especially at the farm level. Suppose initially the farm market is in equilibrium so that farmers and slaughterers have no incentive to change the quantities they are willing to sell or buy at the prevailing price.¹ Now if an exogenous increase in demand occurs the initial equilibrium will be disturbed and a series of forces will come into play as the system adjusts to a new equilibrium. Depending on the form of the producers' price expectations this adjustment process may be stable or unstable, long or short.

To continue with the example, suppose producers expect that the demand increase is permanent and therefore they hold back current production in order to build up the size of the herd. Thus an initial price rise (demand-induced) is further heightened by the actions of producers who want to increase supply, but to do so must withhold animals from short-run slaughter.² This new higher price cannot be

¹ The following example is a distillation of material from three separate sources: Solow [51, p. 6], Jarvis [27, p. 106-143], and Reeves and Hayman [46, p. 134-5].
² Note the claim of some market analysts that the short-run beef supply relation at the farm level is negative.
sustained because eventually an enlarged herd starts producing more animals for slaughter so supply shifts to the right and the price declines. However, just as before, producers form expectations of how far prices will decline and the process begins again in reverse. Now producers begin to liquidate their herds which means that short-run supplies are increased, thus the initial price dip is deepened so that longer-run production can be decreased.

What this example illustrates is that these markets are constantly in flux and that approaching an equilibrium may involve a number of price swings above and below the equilibrium level. In reality a long-run equilibrium will never be reached because none of the basic relationships will remain static for long enough to observe it. Perhaps as Solow [51] suggests, this type of market mechanism is fundamentally unstable. The theory necessary to explain fully this type of equilibration process is not well developed. For example, no one knows how producers form their price expectations; maybe they focus on the price level rather than its rate of change. While no theoretical advances are offered here, the econometric model will try to deal with this problem by attempting to differentiate between long- and short-run price elasticities of supply.

Detailed Specifications for Each Market.

The general principles behind the model specification have been described. Below any modifications to this general structure are outlined in detail for each market level.
Farm Level Functions.

Farm Supply.

Equation (5.10) is the basic specification of the farm supply equation, but it is amended by aspects unique to this particular market. It should be noted that farm supply is often denoted as primary supply because it results from the decisions of the farmer-producers who are first in the stage of processing.

One change in this specification that will be experimented with is the form in which beef prices enter the equation. Since corn is a large proportion of the costs of feeding steers, a number of previous studies have employed the relative level of beef price rather than the absolute level. Thus, the cattle-corn price ratio provides a rough indicator of profitability for the rancher-feeder. When this ratio increases—either because steer prices rise or corn costs fall—the following might occur: ¹

1) more grain feeding is called forth,
2) feedlots prosper and expand,
3) calf prices increase more than heavier feeder steers,
4) grass operators produce more calves and sell them younger,
5) cattle are placed on feed at a younger age, and
6) ranchers have unplanned feed surpluses with expanded feedlot placements leaving fewer cattle on the range.

Thus, the cattle cycle warms up, and this may be manifested in the

¹ Suggested in Jacobs [26].
short-run by a reduction in slaughter in order to allow for herd build-up. But in the longer run, an increase in the beef steer-corn price ratio will bring forth increased slaughter, *ceteris paribus*. The particulars of the lag structure are quite important and are discussed in detail in the econometric estimation techniques section of this chapter.

A final price-related issue is deciding upon the actual variable to be used in the numerator of the steer-corn price ratio. Some analysts might argue that the proper variable is the price of a beef future's contract because this is what a farmer with rational expectations would use in making his production decision. In theory this argument makes perfect sense but it has two practical drawbacks in this case. First, the data used in this study are annual. Beef futures contracts have only been traded since the mid-1960's so the degrees of freedom for estimating the model would be quite restricted. Second, the cattle production process involves very long time lags, perhaps as long as four or five years, which is well beyond the maturities of any existing futures contracts. In general, it would seem that futures prices are the proper means for measuring producer price expectations, but that crop supply modelling is probably a more fruitful area (for example, see Gardner [64]).

A second modification made to the basic formulation in equation (5.10) is that a measure of aggregate herd size is included in the beef supply equation. The rationale for this approach to livestock supply modelling has been examined in a number of theoretical and
empirical studies including Hildreth and Jarrett [24], Myers and Havlicek [31], Reutlinger [47], and Tryfos [54]. To explain how the stock or herd variable can enter the supply equation, consider the following simplified example which is distilled from these previous studies. Beef quantity supplied ($Q_{St}$) is defined as equal to the available supply ($A_{St}$) minus inventory demand ($ID_t$),

$$Q_{St} = A_{St} - ID_t \quad (5A)$$

Available potential supply for slaughter is a linear function of beginning period inventories ($I_t$),

$$A_{St} = b I_t \quad (5B)$$

where the parameter $b$ is positive and represents the normal replacement rate or average percentage of the herd that is slaughtered off each year.

Inventory demand is defined as the difference between beginning period ($I_t$) and end of period ($I_{t+1}$) inventories,

$$ID = I_{t+1} - I_t \quad (5C)$$

Desired inventory for next period $I^{*}_{t+1}$ is a linear function of producers' expectations in period $t$ of future (or next period's, i.e., $t+1$) beef selling prices ($PB_t^*$) in relation to expectations of future factor costs ($PCORN_t^*$)

$$I^{*}_{t+1} = a + c \left( \frac{PB_t^*}{PCORN_t} \right) \quad (5D)$$
Similar to the arguments noted above, all other things equal, the desired inventory will increase (decrease) if producers expect that next period's prices (costs) will be permanently higher.

A final assumption is that there is a partial adjustment process between desired and actual inventory levels,

$$I_{t+1} - I_t = d (I^*_{t+1} - I_t)$$  \hspace{1cm} (5E)

where the parameter $d$ indicates the extent to which actual inventory adjusts towards the desired level, i.e., $0 < d < 1$.

Substituting and simplifying terms yields the quantity supplied as a function of a constant, the expectations as to future prices and costs, and the inventory variable,

$$QS = a' + b' \left( \frac{PB}{PCORN} \right)^*_t + c' I_t$$  \hspace{1cm} (5F)

where $a' = ad$, $b' = cd$, and $c' = (b-d)$. It now becomes clear that the sign of the coefficient $c'$ on the herd variable in the supply equation depends on the relative magnitudes of the parameters $b$ and $d$ which represent the average replacement rate and the stock adjustment factor, respectively. The determination of the sign of the coefficient is therefore an empirical matter. In a model similar to this one Tryfos [54] found $c' < 0$, thereby implying $d > b$.

A negative sign on the herd coefficient in the supply equation also has intuitive appeal. Suppose producers' expectations are that cattle prices will be permanently higher next period. Then, all other things equal, the livestock herd will increase because it will
be more profitable to slaughter a given animal next period rather than this period. However, for the size of the herd to increase, a part of the current livestock supply which would otherwise have been slaughtered must be withheld from current production.

A third consideration is that the basic formulation in equation (5.10) could have been derived (in slightly more general terms) with an assumption about the rate at which technical progress occurs in the industry. It is likely that productivity changes in agriculture have had some degree of effect on farm level supply functions throughout the post-World War II period. For this reason, an index of productivity change in overall agriculture is included as a determinant of beef supply. Unfortunately, a separate series for livestock productivity is not available, but this more explicit approach of using a general agriculture index is still preferable to the alternative of simply using a time trend which assumes that technological change advances at a constant rate.

A last matter for consideration is the effect of weather on cattle supply. Drought conditions have the immediate effect of restricting foraging for grass fed beef. The more important impacts, however, from drought are likely registered on feed prices. Thus, although a suitable weather variable is not available for this analysis, it is not expected that this omission poses a serious problem since the important effect of adverse weather conditions will be picked up by the cost of corn feed. Econometrically the effect of an omitted variable depends on the covariance between the omitted and included
variables. The extent of any possible bias owing to this is judged to be minimal.

Taking all of these modifications into account, the basic farm level supply function that will be tested is

\[ Q_{SB,F} = a_0 + b_1 \left( \frac{P_{B,F}}{PCORN} \right) + a_1 WR_F + a_2 PROD_F + a_3 HERD + e_1 \]  

(5.11)

where

\[ Q_{SB,F} \quad = \quad \text{total commercial beef cattle and calf slaughter live weight, (million pounds)}, \]
\[ P_{B,F} \quad = \quad \text{live animal price of choice grade steers, deflated, (1972 \$/pound)}, \]
\[ PCORN \quad = \quad \text{average price received/paid by farmers for corn, deflated, (1972 \$/bushel)}, \]
\[ WR_F \quad = \quad \text{average hourly earnings for farm workers, deflated, (1972 \$/hour)}, \]
\[ PROD_F \quad = \quad \text{index of total factor productivity change in agriculture}, \]
\[ HERD \quad = \quad \text{number of cattle and calves on farms at the beginning of year, (millions of head)}, \]

and the a's and b_1 are coefficients to be estimated. All variables are annual and expressed in natural logarithms, here and throughout. The parameter, e_1, (like all of the error terms in the equations to follow) is assumed to be a normally distributed random disturbance term with zero mean and constant variance. Based on the preceding theoretical development and discussion the following signs would be

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1 It has been suggested that to the extent that weather significantly affects cattle supply then the assumption of a normally distributed error process may be inappropriate. This is because adverse weather conditions are not normally distributed.
expected for each coefficient:

\[ a_0 > 0; \ a_1 < 0; \ a_2 > 0; \ a_3 < 0; \ \text{and} \ b_1 < 0 \ (\text{short-run}) \ \text{and} \ b_1 > 0 \ (\text{long-run}). \]

In equation (5.11) the cattle-corn price ratio, \( \frac{P_{B,F}}{P_{\text{CORN}}} \), requires some explanation. First, in this section no time subscript is used, but the lag structure is an important matter which is examined in detail in a following section on estimation techniques. Second, the specific form in which the two prices enter the equation is a ratio because it is their relative levels which are of major importance. However, the ratio form also imposes a restriction in that the coefficient \( b_1 \) is forced to be the same for both variables. While this formulation is perhaps not ideal, the data available for this analysis are annual (thereby limiting degrees of freedom) so that use of the ratio form, besides making practical sense in terms of industry behavior also was appealing, on purely technical grounds.

**Farm Demand.**

Farm level demand for beef is derived from the primary demand of final consumers at retail. In fact farm demand is in a sense "doubly derived" because it must be passed back through two intervening marketing levels before reaching the farmer.

In order to demonstrate how retail demands are registered at the farm level, consider the following simplified model of the beef sector.\(^1\)

\(^1\)A similar result is obtained from a different structural model in Learn [35].
(Later sections will expand upon this, especially explaining margin behavior more completely). Following equation (5.2), suppose quantity demanded at retail (QD$_{B,R}$) is a linear function of retail price (P$_{B,R}$), a substitute price (P$_{0,R}$), and disposable income (Y),

\[
QD_{B,R} = a + b P_{B,R} + c P_{0,R} + d Y
\]  

(5.12)

Farm level prices are equal to retail prices minus the farm-retail marketing margin or price spread (M$_{B,F,R}$),

\[
P_{B,F} = P_{B,R} - M_{B,F,R}
\]  

(5.13)
The farm-retail margin is a function of a constant, the quantity of beef marketed at retail, and an index of the costs of marketing services (I),

\[ M_{B,R} = g + h Q_{D,B,R} + j I \] \hspace{1cm} (5.14)

Quantities demanded at retail are directly related to farm quantities by a physical yield relationship such that approximately 44% of the liveweight of an animal eventually reaches the retail consumer,

\[ Q_{D,B,R} = 0.44 Q_{D,B,F} \] \hspace{1cm} (5.15)

Substituting equations (5.12), (5.14), and (5.15) into (5.13) and normalizing on farm quantity yields a farm level demand relation for beef,

\[ Q_{D,B,F} = a' + b' P_{B,F} + c' P_{O,R} + d' Y + j' I \] \hspace{1cm} (5.16)

where \( a' = (a+g)/(1-h)0.44 \); \( b' = 1/(1-h)0.44 \); \( c' = c/(1-h)0.44 \); \( d' = d/(1-h)0.44 \); and \( j' = j/(1-h)0.44 \).

Except for some minor modifications, the basic farm level demand function that will be tested is of the form

\[ Q_{D,B,F} = c_0 + c_1 P_{B,F} + c_2 P_{O,R} + c_3 Y + c_4 I + e_2 \] \hspace{1cm} (5.17)

where

- \( Q_{D,B,F} \) = per capita commercial cattle and calf slaughter, live weight, (pounds/person),
- \( P_{O,R} \) = retail price of beef substitute, e.g., pork, chicken, etc., deflated, (1972 $/pound),
\[ Y = \text{per capita disposable personal income, deflated, (1972 \$/person),} \]

\[ I = \text{index of costs of marketing services,} \]

and the c's are coefficients to be estimated. All variables are expressed in the natural logarithms for the reasons noted in the previous section. The expected signs on the coefficients in the equation are:

\[ c_1 < 0; c_2 > 0; c_3 > 0; \text{ and } c_4 < 0. \]

The reasoning behind signs of the prices and income coefficients should be clear. As for \( c_4 \), the coefficient on the marketing cost index, it is negative because an increase in this variable would increase the farm-retail margin thereby inducing opposite shifts in the farm demand (downward) and retail supply (upward) functions. This effect will be examined more carefully in a following section.

Farm level prices for beef are determined by the intersection of the primary supply and derived demand functions.

**Slaughter Level Functions.**

**Slaughter Supply.**

The supply of dressed carcass beef is derived from the primary supply function at the farm level. Again, equation (5.10) is the basic supply relationship which is amended by the unique characteristics of the packer level. Most of the costs of slaughter are for raw materials; wages are next in importance. Just as for farmers, a rough indicator of profitability for the packer would be the relative level of price. In the present case this index is the ratio of the beef carcass price to the live animal price. When this ratio increases, profit maximizing
packers in the long-run would be induced to increase supply, _ceteris paribus_. The short-run supply function is also likely to be highly price inelastic, if not backward bending, like its counterpart at the farm level. Yet, since so few of the costs of the packer are fixed one would expect that the slaughter level supply function would be much more elastic in the medium- to long-run than at the farm level.

As for the other variables which might possibly enter the supply equation, 1) the wage rate is included as this falls out from the basic theory, 2) inventories are not quite as significant a supply concern as at the farm level because at this stage the product is quite perishable, 3) although productivity in meat packing is undoubtedly a key determinant of the level of supply no such actual time series exists so the index of labor productivity for all-manufacturing is employed as a proxy.

In view of these points, the basic slaughter level supply function to be tested is

\[ QS_{B,S} = d_0 + b_2 \left( \frac{P_{B,S}}{P_{B,F}} \right) + d_1 W_{R,S} + d_2 P_{ROD,S} + e_3 \]  

(5.18)

where

- \( QS_{B,S} = \) total commercial production of beef, carcass weight, (million pounds),
- \( P_{B,S} = \) carcass price of beef, choice grade, deflated, (1972 $/pound),
- \( W_{R,S} = \) average hourly earnings for production workers in meat packing, deflated, (1972 $/hour),
- \( P_{ROD,S} = \) productivity change at the slaughter level,
and the d's and $b_2$ are coefficients to be estimated with expected signs of: $d_0 > 0; d_1 < 0; d_2 > 0$; and $b_2 < 0$ (short-run), and $b_2 > 0$ (long-run).

**Slaughter Demand.**

Slaughter level demand for beef is also derived from the primary demand for the finished product by ultimate consumers. It could easily be demonstrated how these demands are passed back to the slaughter level, but since this was shown for farm level demand, completeness will give way to brevity. The only differences in the derivation would be that: 1) the carcass-retail margin would replace the farm-retail margin in equations (5.13) and (5.14), and 2) the physical yield is such that 71% of the carcass weight makes its way to the retail level. With these changes, the basic slaughter level demand function is

$$Q_{D_{BS}} = g_0 + g_1 P_{BS} + g_2 P_{0R} + g_3 Y + g_4 I + e $$  (5.19)

where

$$Q_{D_{BS}} = \text{per capita commercial production of beef, carcass weight, (pounds/person), and}$$

the g's are coefficients to be estimated. Similar to the farm level demand function, the expected signs on the coefficients are: $g_1 < 0; g_2 > 0; g_3 > 0; \text{and } g_4 < 0$.

Slaughter level prices for beef are determined by the intersection of the two derived supply and demand functions for the packer.
Retail Level Functions.

Retail Supply.

Beef products at the retail level are supplied through several types of outlets, including grocery stores, hotels, restaurants, and institutions. These separate groups are modelled as a homogeneous class whose goal is to maximize profit in response to prices and costs that are given. Aggregate supply at the retail level is also a derived supply because it results from decisions made at the farm level. Therefore, retail supply in total will be relatively inelastic with respect to price in the short-run, with the precise degree of inelasticity depending on margin behavior.

As with the other market levels, the retail price of beef is expressed as a profitability ratio by dividing it by the cost of beef to the retailer, $P_{B,R}$. Profit maximizing retail producers will attempt to sell more meat and increase supply over time as this ratio increases. Wages and productivity are the other key determinants of retail supply. No data is available for total factor productivity at the retail level so the next best alternative, labor productivity in retail food stores is used as a proxy. Based on the fundamental supply relationship in equation (5.10) and these other issues, the basic retail level supply function is

$$Q_{B,R} = h_0 + b_3 \left( \frac{P_{B,R}}{P_{B,S}} \right) + h_1 \frac{WR}{R} + h_2 \frac{PROD}{R} + e_5$$

(5.20)
where

\[ QS_{B,R} = \text{total civilian consumption of beef, retail weight, (million pounds)}, \]

\[ P_{B,R} = \text{retail price of beef, choice grade, deflated, (1972 \$/pound)}, \]

\[ WR_{R} = \text{average hourly earnings for non-supervisory workers in retail food stores, deflated, (1972 \$/hour)}, \]

\[ PROD_{R} = \text{productivity change at the retail level} \]

and the \( h \)'s and \( b_3 \) are coefficients with expected signs of: \( h_0 > 0; \) \( h_1 < 0; \) \( h_2 > 0; \) \( b_3 < 0 \) (short-run), and \( b_3 > 0 \) (long-run).

**Retail Demand.**

Demand at the retail level is termed primary demand and exists in its most fundamental form as separate demands for individual retail cuts of beef, e.g., steaks, roasts, hamburg. All of these demands are aggregated to yield the basic retail level beef demand function

\[ QD_{B,R} = k_0 + k_1 P_{B,R} + k_2 P_{O,R} + k_3 Y + e \]  \hspace{1cm} (5.21)

where

\[ QD_{B,R} = \text{per capita civilian consumption of beef, retail weight, (pounds/person)}, \]

and the \( k \)'s are coefficients to be estimated. Clearly in this more aggregate form, \( P_{B,R} \) represents a price which is the weighted average of all the prices for the various cuts of beef. As indicated earlier, the signs to be expected from the theory of consumer behavior are:

\( k_1 < 0; k_2 > 0; \) and \( k_3 > 0. \)

Retail level prices for beef are determined by the intersection
of the primary demand and derived supply functions for the retailer.

Marketing Margin Functions.

The above system of six simultaneous equations represents a more or less complete description of the process of price determination in these markets. However, there is another matter of interest which relates back to the literature review section of this chapter where a number of extant econometric models of the livestock or beef economy are discussed. It was noted that most beef models include a marketing margin (or price spread) equation which links the farm supply level with retail demand. Most of these models have used an ad hoc approach to margin specification. In this section a more rigorous method is developed which shows that marketing margins are simply reduced form equations which fall out of the six underlying structural equations.

The price spread or marketing margin is an oft-used indicator in agriculture.¹ Technically, a margin is the difference between the price per unit of the food product at one level of the production-marketing system and the price of an equivalent quantity of the commodity at another level of the system. The spread is thus a type of value added measure and deals with various transformations that

¹Margins have long been a matter of joint farmer-consumer concern, see NCFM [42]. Explanations of how they are calculated and some of their weaknesses can be found in USDA [58], Williams and Stout [63, p. 590-616], COWPS [56], and Congressional hearings [55, p. 399-482]. Simple graphic analyses of how margins shift in response to market forces can be found in Tomek and Robinson [52, p. 109 ff] and Dahl and Hammond [9, p. 139-163]. A more formal analysis of these effects is provided by Gardner [13].
the product undergoes on its way from the farm to the grocery store.

For beef products there are three price spreads of interest. First the farm-carcass spread measures the costs of marketing cattle, slaughtering the animal, and transporting the dressed beef carcass to the city where consumed. Second, the carcass-retail spread includes the gross margin for retailing as well as other intermediate marketing services, e.g., breaking carcasses, fabricating, wholesaling, and local delivery to retailers. Third, the farm-retail spread is simply the total per unit marketing charge and is the sum of the farm-carcass and carcass-retail spreads.

To calculate spreads requires estimates of value and equivalent quantities at each level of processing. For example, a 1,000 pound steer after slaughtering yields about 620 pounds of carcass weight meat and after processing yields some 440 pounds of meat in retail cuts. Thus packer and farm level equivalents must be proportionately larger than the products ultimately bought by the retail consumer. USDA yields currently in use are: 2.28 pounds of live animal, or 1.41 of carcass weight, are required to product 1 pound of retail beef. Also, in calculating margins a weighted average retail price must be derived since there are some 29 different cuts into which a carcass is broken.

Once retail, slaughter, and farm level prices are obtained, the retail-equivalent values are simply the product of the conversion factor and the price.¹ For example, if the retail price were $1.40 per pound

¹Prices at the farm and wholesale level are converted to retail equivalent values and denoted as such by an asterisk. Part of the weight loss from farm to wholesale is waste and part is salable by-products. Byproducts are not included in the price spread data as all values are based on meat sold at retail [58, p.2].
and the liveweight farm price per pound is $0.40, then the farm-
retail spread is $1.40 - (2.28)(0.40) = $1.40 - 0.91 = $0.49. The so-
called farmers' share is 0.91/1.40, or 65 percent. The farm-carcass
and carcass-retail margins can be computed in a similar manner.

Now the focus will be shifted to how margins are determined,
first by simple graphic explanation and then with more formal methods.
Suppose that the farm, packer, and retail demand for and supply of beef
could be characterized as in Figure 5.1. The subscripts F, S, and R
refer as before to the three different levels of the market: farm,
slaughter, and retail. On the demand side, \( D_R \), the retail demand
schedule is the primary demand function in the sense that it is deter-
mined by the response of final consumers. \( D_S \) and \( D_F \) are derived demand
functions in that they represent the transmission of the demands of
ultimate consumers back to the packer and farm levels. Similar rela-
tions exist on the supply side, except that the farm level supply
function, \( S_F \), is primary supply and \( S_S \) and \( S_R \) are the derived
schedules.

In this simplified example, it is assumed that the supply schedules
are positively sloped, linear, and parallel whereas the demand schedules
are negatively sloped, linear, and parallel. This implies that the
meat-packing and retailing industries exhibit constant costs, i.e.,
the supply of marketing services is completely elastic, thus the margins
are independent of the quantity marketed. In this idealized case the
price spreads can simply be read off of Figure 5.1 as the vertical
difference between the appropriate demand or supply schedules. For
example, the farm-carcass spread is \( P_S^* - P_F^* \), the carcass-retail spread
Price Per Unit of Beef ($/retail pound)

Quantity of Beef (Pounds -- in retail equivalent units)

Farm-Carcass Spread \((M_{F,S})\): \(P^*_S - P^*_F\)

Carcass-Retail Spread \((M_{S,R})\): \(P^*_R - P^*_S\)

Farm-Retail Spread \((M_{F,R})\): \(P^*_R - P^*_F\)

Figure 5.1. Beef Price Spread Determination Under Pure Competition.
is $P_R - P_S^*$, and the farm retail spread is $P_R - P_F^*$. Equilibrium prices in each market are determined by the intersection of the respective supply and demand schedules.

The picture presented here of price and margin behavior is too simple to be realistically relevant for two reasons. First, neither set of demand nor supply schedules is probably parallel. Second, the absolute value of the slopes of supply and demand need not be equal. What happens when these assumptions are violated?

If the processing and distribution industries are not characterized by constant cost then the margins will be a function of the quantity marketed as well as costs. The most likely condition is that there is some degree of increasing returns to scale in both meatpacking and retailing. If so, then price spreads should decline over some limited range as quantities increase. (Further explanation of this effect is provided below).

To see what happens when the absolute value of the slopes of the supply and demand schedules are unequal the example is extended to consider the following. Suppose there is an equal increase in both retail and packer wages so that the farm-retail margins widens. In Figure 5.1, this would show up as shifts in the derived functions of supply and demand with respect to the primary functions. Both $D_S$ and $D_P$, the derived demand functions, would shift downward while $S_S$ and $S_R$ shift upward. (Since the assumed change in wages is just a change in packer and retailer input costs and not a change in the fundamental nature of the product being supplied or demanded, the primary functions
would remain fixed). These shifts in the derived schedules would result in an increase in retail price and a decrease in farm price as both the farm-carcass and carcass-retail margin would increase and quantity marketed would decline. Now if the absolute values of all slopes are equal as in Figure 5.1 then the change in the margins would induce equal, but opposite, changes in retail and farm prices. However, if supply is less elastic than demand as is probably the case in beef, then more of the impact of a margin change will fall on the farm price. In the extreme case of perfectly inelastic supply, the full impact of a change in the farm-carcass margin would be on the farm price.

These relationships can be examined more formally within the
structure of the econometric model. Initially it will be assumed that there is simply a monolithic marketing industry which in the stage of processing sits between the farmer and the consumer. The marketing industry's product is in the form of processing and distribution services which are part and parcel of what consumers demand when they buy the commodity. In effect, the marketing industry exists so that consumers do not have to go directly to the farmer for their purchases. Following the methods developed in the preceding sections, suppose that this system of production-distribution-consumption could be described by four linear behavioral relations:

Consumers' demand: \[ Q_R = a + b P_R + c Y \] (5.22)

Marketing industry's supply: \[ Q_R = d + g P_R + h I \] (5.23)

Marketing industry's demand: \[ Q_F = j + k P_F + m Y \] (5.24)

Farmers' supply: \[ Q_F = n + r P_F + s X \] (5.25)

where, as before, \( Q_R \) and \( Q_F \) are quantities demanded at retail and supplied at the farm, \( P_R \) and \( P_F \) are the respective prices of output, \( Y \) is consumer income, \( I \) is an index of the costs of marketing services, and \( X \) is a measure of farm input costs. Also, this simple model abstracts from the physical yield issue, so in equilibrium \( Q_R = Q_F \), thus clearing each market.

---

1 Part of what follows is based upon the separate approaches of George and King [14] and Gardner [13].
Equations (5.22) and (5.25) are similar to ones developed in prior sections and require no explanation. In equation (5.23), the marketing industry supplies what consumers demand. The marketer's supply decision is derived from the farmer's supply decision and is based upon what the marketer can sell his product for and what it cost to produce it. In equation (5.24) the marketing industry's demand for the farm product is derived from the consumers' demand so it is a function of the cost of the commodity quoted by the farmer and on an exogenous measure of how the primary demand function shifts.

Within this system of four simultaneous equations the farm-retail margin, \( M_{FR} \), can be derived as the difference between the retail and farm prices. By solving equations (5.22) and (5.23) for \( P_R \) and solving (5.24) and (5.25) for \( P_F \), taking the difference and simplifying one obtains

\[
M_{FR} = P_F - P_R = a' + b' Y + c' I + d' X
\]

where \( a' = \frac{a-d}{g-b} - \frac{n-j}{k-r} \); \( b' = \frac{c}{d-b} + \frac{m}{k-r} \); \( c' = \frac{-h}{g-b} \); and \( d' = \frac{-s}{k-r} \).

Deriving the margin in this way properly emphasizes the role of different market forces in price spread determination. It is now clear that the marketing margin is a reduced form of a larger system of equations in which both retail demand and farm supply effects interact. This result is fundamentally different from other econometric models of margin behavior which have typically adopted the naive assumption that retail prices are some mixture of an absolute and percentage markup over farm prices. That approach tends to obscure the real underlying
forces that determine the price spread, but this fact is lost because such a high $R^2$ is obtained when farm price is regressed on retail price. Most empirical attempts at price margin modelling are examples of when a good fit, i.e., a $R^2$ close to 1.0, actually explains very little.

The functional form that equation (5.26) should take and the expected signs of the coefficients are not altogether clear. For convenience and ease of comparability with other equations in the model, only the multiplicative form is estimated. As for the coefficients, under normal conditions, i.e., in markets where supply functions are positively sloped and demand functions are negatively sloped, $c'$ would unambiguously be positive and $d'$ negative. The sign on $b'$ is harder to specify because it depends on the relative elasticity of the marketing industry's supply and demand curves, as well as price elasticity at the farm and consumer level. Applying some estimates of these elasticities as reported in Table 5.1 leads one to conclude in most instances, beef included, that $b'$ would be negative. The same conclusion is reached for most agricultural products in general via a different route by Gardner [13].

These theoretical considerations can be implemented in terms of separate specifications for the farm-carcass and the carcass-retail margins. The only modification to the general model given in equation (5.26) that might more accurately reflect conditions in beef markets is the inclusion of a quantity variable. This would capture the effect of possible economies of scale existing over some limited range of output in either slaughtering or retailing. If such economies existed then
increases in quantity marketed would be expected to decrease margins.

Waugh [61] points out that quantity can also stand as a proxy for the effect of capacity utilization. When an industry is close to its full capacity, an increase in quantity may force average (and marginal) costs up and thereby widen or increase marketing margins. However, "the average costs of both processing and retailing may go down if an industry has unused capacity or labor that is not fully used" [61, p. 36]. Unfortunately capacity utilization figures do not exist as a time series for the slaughter or retail industries. What is known about these separate markets suggests that if a quantity variable has any effect on margins it should in most cases be a negative one.

One final factor that a priori should have a strong effect on margins is productivity. When productivity is increasing it will tend to decrease costs per unit of output and thereby directly lower margins.

In view of this discussion, the basic farm-carcass marketing margin that will be tested is

\[
M_{F,S} = P_{B,S}^* - P_{B,F}^* = m_0 + m_1 Y + m_2 WR_S + m_3 PCORN + m_4 QS_{B,S} + m_5 PROD + e
\]

(5.27)

where all variables\(^1\) are as defined in the preceding sections and the expected signs on the coefficients are \(m_1 < 0; m_2 > 0; m_3 < 0; m_4 < 0;\)

\(^1\) In computing the margins, farm and carcass level prices are marked with an asterisk because they are stated here as retail-equivalent values. See discussion at beginning of this section for explanation for this procedure.
and $m_5 < 0$.

Similarly the carcass-retail margin, $M_{S,R}$, that will be tested is of the form

$$M_{S,R} = P_{B,R} - P_{B,S} = n_0 + n_1 Y + n_2 Y + n_3 P_{CORN} + n_4 Q_{S,B,R} + n_5 P_{R} + e_{8} \quad (5.28)$$

The expected signs for these coefficients would be $n_1 < 0$; $n_2 > 0$; $n_3 < 0$; $n_4 < 0$; and $n_5 < 0$.

Of course, since equations (5.27) and (5.28) are a reduced form of the six structural equations, they do not strictly have to be estimated econometrically. The parameters of the margin equations should be retrievable from the estimates of the parameters for the supply and demand equations. As a consistency check, both of these approaches are used as discussed in the next chapter.
The preceding sections have provided a detailed specification for the process of price and quantity determination in the three principal markets for beef. All of the basic structural equations are collected together in Table 5.2. This is essentially the model that will be estimated in the following chapter. However, before actually estimating the model's parameters the appropriate econometric methods must be described.

**Estimation techniques.**

A fundamental distinction prevails in beef markets between short-run and long-run supply price elasticities. This point was raised earlier but bears repeating. If producers expect that prices they receive for beef will permanently be higher in future periods, *ceteris paribus*, then they must hold back on current slaughter in order to build up the size of the breeding herd.¹ This means that future increases in production occur at the expense of current production. Thus one would expect to find that short-run beef supply price elasticities would be backward bending, i.e., 

\[ e_{sr} = \left( \frac{\partial Q}{\partial P} \right) \left( \frac{P}{Q} \right) < 0; \]

whereas in the long-run, which for a steer can be as long as four years, the supply price elasticity would be positive, as the increased quantities were ultimately

¹ Note that price expectations are discussed here in terms of permanent future levels of price. If producers expected that prices were only to be transitorily higher in the future, they might respond entirely differently by culling the size of the herd, and one would observe 

\[ e_{sr} > 0. \]
Table 5.2 Specification of Beef Model.

Farm supply
\[ QS_{B,F} = a_0 + b_1 P_{B,F} + a_1 WR_F + a_2 PROD_F + a_3 HERD + e_1 \] (5.11)

Farm demand
\[ QD_{B,F} = c_0 + c_1 P_{B,F} + c_2 PCP_R + c_3 Y + c_4 I + e_2 \] (5.17)

Slaughter supply
\[ QS_{B,S} = d_0 + b_2 P_{B,S} + d_1 WR_S + d_2 PROD_S + e_3 \] (5.18)

Slaughter demand
\[ QD_{B,S} = g_0 + g_1 P_{B,S} + g_2 PCP_R + g_3 Y + g_4 I + e_4 \] (5.19)

Retail supply
\[ QS_{B,R} = h_0 + b_3 P_{B,R} + h_1 WR_R + h_2 PROD_R + e_5 \] (5.20)

Retail demand
\[ QD_{B,R} = k_0 + k_1 P_{B,R} + k_2 PCP_R + k_3 Y + e_6 \] (5.21)

Farm-carcass marketing margin
\[ M_{F,S} = m_0 + m_1 Y + m_2 WR_S + m_3 PCORN + m_4 QS_{B,S} + m_5 PROD_S + e_7 \] (5.27)

Carcass-retail margin
\[ M_{S,R} = n_0 + n_2 WR_R + n_3 PCORN + n_4 QS_{B,R} + n_5 PROD_R + e_8 \] (5.28)

Identities
\[ QS_{B,F} = QD_{B,F} + POP \]
\[ QS_{B,S} = QD_{B,S} + POP \]
\[ QS_{B,R} = QD_{B,R} + POP \]

---

1 All variables are expressed in natural logarithms. See sources and full definitions of variables in Appendix 3.
where

\[ \text{HERD} = \text{number of cattle and calves on farms at the beginning of year, (millions of head)}, \]

\[ \text{M}_{FS} = \text{farm-carcass price spread, calculated as difference between farm value and carcass value, i.e., } P^*_B,F - P^*_B,S, \text{ deflated, (1972 $/retail equivalent pound)}, \]

\[ \text{M}_{SR} = \text{carcass-retail price spread, calculated as difference between retail price and carcass value, i.e., } P_{B,R} - P^*_B,S, \text{ deflated, (1972 $/retail equivalent pound)}, \]

\[ P_{B,F} = \text{live animal price of Choice grade steers at 7 leading public stockyards and average of quotations to California feeders and ranchers, deflated, (1972 $/pound)}, \]

\[ P^*_B,F = \text{net farm value obtained by subtracting a byproduct allowance from gross farm value; represents payment to farmer for quantity of Choice grade beef cattle equivalent to 1 pound of retail cuts, deflated (1972 $/retail equivalent pound)}, \]

\[ P_{B,F} \quad \frac{\text{PCORN}}{} = \text{beef steer-corn price ratio, Omaha basis,} \]

\[ P_{B,R} = \text{average retail price of beef, for over 20 retail cuts of beef, Choice grade, calculated from BLS data and prices reported by 40 retail chain divisions, deflated, (1972 $/pound)}, \]

\[ P_{B,S} = \text{weighted average of price quotations for primarily 600-700 pound carlots of steer carcasses, Choice grade, at Chicago and West Coast markets, deflated (1972 $/pound)}, \]

\[ P^*_B,S = \text{wholesale value of quantity of Choice carcass beef equivalent to 1 pound of retail cuts, deflated (1972 $/retail equivalent pound)}, \]

\[ \text{PCORN} = \text{average price of corn received by farmers, deflated (1972 $/bushel)}, \]

\[ P_{CP,R} = \text{weighted average chicken-pork retail price, computed from } P_{C,R} \text{ and } P_{P,R}, \text{ deflated (1972 $/pound)}, \]
Table 5.2 (Continued)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(PC_R)</td>
<td>retail price of broilers, whole or cut-up, in retail stores in urban areas, deflated, (1972 $/pound),</td>
</tr>
<tr>
<td>POP</td>
<td>U.S. population, (thousands of persons),</td>
</tr>
<tr>
<td>(PO)</td>
<td>retail price of pork, deflated, (1972 $/pound),</td>
</tr>
<tr>
<td>PRODF</td>
<td>index of farm output per unit of input, (1967 = 100),</td>
</tr>
<tr>
<td>PRODR</td>
<td>index of output per hour of all persons in retail food stores, (1967 = 100),</td>
</tr>
<tr>
<td>PRODS</td>
<td>index of output per man-hour of all persons in all-manufacturing, (1967 = 100),</td>
</tr>
<tr>
<td>QDB,F</td>
<td>per capita commercial cattle and calf slaughter, live weight, (pounds/person),</td>
</tr>
<tr>
<td>QDB,R</td>
<td>per capita civilian consumption of beef, retail weight, (pounds/person),</td>
</tr>
<tr>
<td>QDB,S</td>
<td>per capita commercial production of beef, carcass weight, (pounds/person),</td>
</tr>
<tr>
<td>QS,B,F</td>
<td>total commercial beef cattle and calf slaughter, live weight, (million pounds),</td>
</tr>
<tr>
<td>QS,B,R</td>
<td>total civilian consumption of beef, retail weight, (million pounds),</td>
</tr>
<tr>
<td>QS,B,S</td>
<td>total commercial production of beef, carcass weight, (million pounds),</td>
</tr>
<tr>
<td>WR,F</td>
<td>average hourly earnings for farm workers without board or room, deflated, (1972 $/hour),</td>
</tr>
<tr>
<td>WR,R</td>
<td>average hourly earnings for non-supervisory workers in retail food stores, deflated, (1972 $/hour),</td>
</tr>
<tr>
<td>WR,S</td>
<td>average hourly earnings for production workers in meat-packing plants, deflated, (1972 $/hour),</td>
</tr>
<tr>
<td>Y</td>
<td>per capita disposable personal income, deflated, (1972 $/person).</td>
</tr>
</tbody>
</table>
brought forth.

In order to capture this phenomenon of the short- vs. long-run, the coefficients on price in each of the supply equations, i.e., $b_1$, $b_2$, and $b_3$ in Table 5.2, are estimated as a polynomial distributed lag (PDL). To explain this procedure, assume for the moment that supply $(QS)$ is solely a linear function of price $(P)$ in the current and $k$ previous periods,

$$QS_t = \beta_0 P_t + \beta_1 P_{t-1} + \ldots + \beta_k P_{t-k} + u_t \quad (5.29)$$

and $u_t$ is assumed to be a well-behaved disturbance term. This equation could be estimated by ordinary least squares (OLS) but severe problems with multicollinearity are likely to result if the length of the lag $k$ is more than just 1 or 2 periods, thereby yielding inefficient estimates of the coefficients; also degrees of freedom can quickly be exhausted if $k$ is large.

Almon [2] has suggested a scheme which deals with these problems by restricting the $\beta$'s to lie on a polynomial of degree $r$, typically a fairly low order will suffice. This approach allows one to approximate the $k$ lag weights by polynomial interpolation. Thus, suppose that for example $r = 2$ and $k = 4$, then to obtain the $\beta$'s we have the following system

$$\beta_0 = z_0$$
$$\beta_1 = z_0 + z_1 + z_2$$

---

1 A more complete discussion is in Johnston [29, pp. 292-300], from which this present treatment is adopted.
\[ \beta_2 = z_0 + 2z_1 + 4z_2 \] (5.30)

\[ \beta_3 = z_0 + 3z_1 + 9z_2 \]

\[ \beta_4 = z_0 + 4z_1 + 16z_2 \]

which expresses the five unknown \( \beta \)'s in terms of three unknown \( z \)'s.

Substituting (5.30) into 5.29) yields

\[ Q_{St} = z_0 (P_t + P_{t-1} + \ldots + P_{t-4}) \]

\[ + z_1 (P_{t-1} + 2P_{t-2} + 3P_{t-3} + 4P_{t-4}) \]

\[ + z_2 (P_{t-1} + 4P_{t-2} + 9P_{t-3} + 16P_{t-4}) + u_t \]

Equation (5.31) can then be estimated by OLS and the \( \hat{z} \)'s, the estimates of the \( z \)'s, substituted back into (5.30) to obtain the \( \hat{\beta} \)'s.

If this particular framework were applied to the supply equations in Table 5.2, then the three equations could be rewritten as

**Farm supply**

\[ Q_{S,F,t}^{BF} = a_0 + \sum_{\ell=0}^{k_F} \beta_{P,F} P_{t-\ell} + a_1 WR_F,t + a_2 Prod_F,t \]

\[ + a_3 \text{HERD}_t + e_1 \] (5.11a)

**Slaughter supply**

\[ Q_{S,S} = d_0 + \sum_{\ell=0}^{k_S} \beta_{S,F} P_{t-\ell} + d_1 WR_S + d_2 \text{PROD}_S + e_3 \] (5.18a)

**Retail supply**

\[ Q_{S,R} = h_0 + \sum_{\ell=0}^{k_R} \beta_{R,F} P_{t-\ell} + h_1 WR_R + h_2 Prod_R + e_5 \] (5.20a)

where all variables are defined as before.

With the supply equations rewritten in this form, the \( \beta \)'s are now the coefficients to be estimated and since the equations are in the
double log form, the $\beta$'s can be directly interpreted as supply elasticities. Because this model will be estimated with annual data, the coefficients for $k=0$, that is the contemporaneous period with a zero lag, can be viewed as estimates of the short-run elasticities of supply for each market level. The long-run elasticities are simply the summation from $k$ equal to 0 to $k$ of the separate coefficients for each period in the lag at each market level.$^1$

In order to implement the PDL structure, one must choose values for $k$ and $r$, the length of the lag and degree of the polynomial. There is generally little theory to guide one's choice. Fortunately, however, the biological make-up of cattle does suggest that a lag of four years or less would be a likely point at which to begin experimentation. Most practitioners have found that a polynomial of a fairly low order, usually fourth degree or less, will adequately describe the function under study. In the following chapter, results are provided for several different values of $k$ and $r$. Also, no zero constraints are placed on any of the PDL equations because others have found that such constraints tend to bias the shape of the distribution of lag weights [39].

It should be noted that the PDL model, especially in the present

\[ e_{SR} = \beta_k \bigg|_{k=0} , \quad e_{LR} = \sum_{k=0}^{k} \beta_k. \]
case, is far superior to other types of distributed lag models, most importantly the Koyck type of geometric lag. Besides inducing some unwanted econometric problems, the Koyck lag is an inappropriate vehicle for estimating cattle supply response because it forces the lagged values of price to decline geometrically through time. As noted above, there is good reason to believe that supply response might at first be negative and only after time for breeding would supply increase in response to a positive price change. The fundamental difference between these two modelling alternatives is shown in Figure 5.

According to theory one might expect that cattle farmers and feeders behave as in the solid curve in Figure 5.2 where the parabolic shape traces out the set of reaction coefficients, the $\beta$'s. Contrariwise, if a Koyck formulation were used to estimate the model, the dotted line is the more likely result. The Koyck model would fail to explain a great deal of the market response because by construction the lag weights must decline through time with the largest effect coming in the first period. In an analysis of hog supply response which explicitly compared geometric and polynomial distributed lag models, it was found that "the time path of adjustment to a price change is considerably different between the two models." [38, p. 20]. Since, the PDL model in theory seems to conform better to actual conditions in livestock markets, it is the only one tested in the chapter to follow.

To date, there have been a few models in the literature which have estimated agricultural supply functions using a PDL model. Wickens and Greenfield [62] apply this method to the Brazilian coffee market.
Figure 5.2 Hypothetical Lag Distributions.
Mielke [39], [40], and Mielke et al. [38] analyze different aspects of the supply of U.S. and Canadian hogs. The only published application of PDL to the beef sector is Kulshreshtha's [32] analysis of Canadian cattle supply.¹

Whereas all of these previous models using PDL have been relatively successful in explaining variation in agricultural supply, they are all subject to a major technical flaw in that they fail to employ simultaneous-equations methods. Even though most of these studies clearly recognize that the supply equation is part of system of equations in which price and quantity are determined simultaneously, they use single-equation techniques when estimating the PDL model. It is well known that ordinary least squares (OLS) produces biased and inconsistent estimates when applied to an equation containing more than one current endogenous variable.

In order to make the point clear, consider equation (5.11a) and assume that \( k_F \), the length of the lag, is equal to 2,

\[
Q_{SB,F,t} = a_0 + \beta_{F,0} \left( \frac{P_{B,F}}{PCORN} \right)_t + \beta_{F,1} \left( \frac{P_{B,F}}{PCORN} \right)_{t-1} + \beta_{F,2} \left( \frac{P_{B,F}}{PCORN} \right)_{t-2} + a_1 WR_{F,t} + a_2 PROD_{F,t} + a_3 HERD_t + e_1 
\]

(5.11a)

Written in this form it is easy to see that the second term on the right-hand side is contemporaneous with the dependent variable. Since \( P_{B,F} \) is also endogenous to the entire system, the disturbance term, \( e_1 \), and \( P_{B,F} \) will be correlated thereby causing the application of OLS

¹ See results in Table 5.1 above.
to yield biased and inconsistent estimates of the \(a\)'s and \(b\)'s.

The most direct and widely used method for dealing with this problem is two-stage least-squares (2SLS).\(^1\) In terms of the current model as described in Table 5.2, 2SLS would be applied to each equation seriatim with all exogenous and predetermined variables in the system serving as instruments. The basic point can again be explained by referring to equation (5.1la). Since \(P_{B,F,t}\) and \(e\) are correlated, the stochastic component of \(P_{B,F,t}\) associated with \(e\) can be eliminated by construction by running a separate regression of \(P_{B,F,t}\) on all of the predetermined (lagged endogenous and exogenous) variables in the entire system of equations. The new estimates of \(P_{B,F,t}\), call them \(^{\hat{}} P_{B,F,t}\), can now be inserted into equation (5.1la) in place of the original \(P_{B,F,t}\) and OLS applied to this revised equation. It can be demonstrated rigorously that 2SLS applied in this way yields consistent estimates of the parameters of the equation system, as long as there is no autocorrelation.

A final matter of concern before this model can be estimated is the issue of identifiability of the structural parameters. Since a distributed lag will be used to estimate the supply equations, Table 5.2 should be updated to show that each supply equation would include one or

\(^1\) Note that the possibility for cross-equation correlation of error terms in a system of equations calls for the use of three-stage least squares (3SLS), a complete system method which is applied to all equations in the system simultaneously rather than one-by-one as with 2SLS. Unfortunately, the data base available for estimating the system of equations in Table 5.2 has an annual periodicity running from 1949 to the present. Consequently there was not a large enough sample from which to estimate the model using 3SLS. This leads to some unavoidable inefficiency in the parameter estimates obtained with 2SLS depending on the extent of cross-equation correlation of errors.
more lagged price ratios thereby increasing the number of predetermined variables in the system. In this revised form, the model as specified, and each equation in it, satisfies the order condition, a necessary condition for identifiability. In fact, each equation is overidentified because there are many more excluded predetermined variables than included endogenous variables in all of the equations. This poses no problem so long as 2SLS is used.
References


Chapter 6. Results from Estimation of Econometric Beef Model.

Introduction

The previous chapter dealt with a detailed theoretical specification of an econometric model of the supply and demand for cattle and beef. In this chapter the statistical results of estimating that model are presented. Because some degree of experimentation is involved in the modeling process, a typical or preferred set of results is discussed first; following this are some alternative regression results.

The results presented below are from regressions run on a sample of annual data covering the twenty-four year period, 1950-73. All variables used in the analysis are defined and their sources listed in Appendix 3. Recall from the discussion in the previous chapter that equations are estimated by two-stage least squares (2SLS) with the predetermined variables in the model serving as instruments.

Estimated Equations For Farm Level

Farm Supply

In general the farm supply equation was the most difficult one to fit to the data. Several slightly different specifications were tried, but none were entirely successful in capturing the variety of economic effects which determine primary supply response.
A typical equation obtained was (standard errors in parentheses),

$$Q_{SB, F} = 3.86 + 0.10 \left( \frac{P_{B, F}}{FC} \right)_{t=0} + \sum_{\ell=1}^{5} \beta_{F, \ell} \left( \frac{P_{B, F}}{FC} \right)_{t-\ell} + 1.64 \text{ PROD}_F - 0.10 \text{ HERD}$$

(6.1)

Range: 1955-73  \quad R^2 = 0.84  \quad S.E. = 0.07

$$\sum_{\ell=1}^{5} \beta_{F, \ell} = 0.14  \quad D.W. = 1.15  \quad r = 2$$

The results in equation (6.1) show that farm productivity, \text{PROD}_F, was a major determinant of farm beef supply over this period. The herd size variable, \text{HERD}, enters with the correct sign but is not significantly different from zero.

The ratio of beef price to feed cost index provided some interesting results. For the contemporaneous period, the coefficient on $\frac{P_{B, F}}{FC}$ is 0.10 but is not different from zero at the 0.05 level of significance.

---

1 The results reported throughout this chapter are in a standard format. The coefficients reported can be interpreted as elasticities because all equations were run the log-log form. Beneath each coefficient is its standard error in parentheses. The Range gives both the period over which the regression was run and implicitly the number of observations since annual data were used. S.E. is the standard error of the regression. For the supply equations, the sum of the estimates of the lag coefficients is indicated by, $k \sum_{\ell=1}^{j \times \ell} \hat{\beta}_{j, \ell}$, where $j$ is the market level, $k$ is the length of lag, and $\ell$ is the time period. D.W. is the Durbin-Watson statistic and $r$ is the degree of the polynomial. In some equations, a value for $\hat{\rho}$ is reported which is the estimate of the serial correlation coefficient obtained from the Cochrane-Orcutt procedure.
significance so the short-run supply price elasticity would be highly inelastic. However the lagged coefficients provide a different picture of the long-run. Although the sum of the five lag coefficients is not statistically significant from zero, note in Figure 6.1 the results for the individual coefficients. The separate coefficients for the 2nd, 3rd and 5th lagged periods are all statistically significant from zero at better than the .02 level. The 1st and 4th period coefficients are not different from zero, but this is as one might expect. Since this equation was estimated with an Almon lag the lagged coefficients are constrained to lie on a polynomial, and when it passes through zero, as in the 1st and 4th periods, the coefficients should be approximately equal to zero. Thus, the pattern revealed by the lag coefficients in Figure 6.1 is one of initial inelasticity, followed by two periods in which supply is actually backward bending, another period of inelasticity, and then in the final period, t-5, supply responds relatively sharply.

It is clear from Figure 6.1 that the set of PDL coefficients exhibits a U-shape as opposed to the more normal inverted-U shown in Figure 5.2 of the previous chapter.

A naive observer might be encouraged by these results whereas someone more astute might note that "there's less here than meets the eye."\(^1\)

Afterall, the Durbin-Watson statistic is suspiciously low indicating the possibility of positive serial correlation which would make these results

\(^1\)The quote has been attributed to Tallulah Bankhead.
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Estimated Coefficient $\hat{\beta}_{F,t}$ (S.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-0</td>
<td>0.10 (0.16)</td>
</tr>
<tr>
<td>t-1</td>
<td>0.04 (0.25)</td>
</tr>
<tr>
<td>t-2</td>
<td>-0.36 (0.12)</td>
</tr>
<tr>
<td>t-3</td>
<td>-0.40 (0.16)</td>
</tr>
<tr>
<td>t-4</td>
<td>-0.06 (0.12)</td>
</tr>
<tr>
<td>t-5</td>
<td>0.65 (0.23)</td>
</tr>
</tbody>
</table>

Supply Elasticities

$e_{SR} = 0.10$
$e_{LR} = -0.03$

Figure 6.1. Plot of Lag Coefficients for Equation (6.1)
appear to be better than they actually are, i.e., the standard errors
would be biased toward zero.¹ To test for serially correlated errors,
the same regression was run except for the inclusion of a correction
for autocorrelation,² with the following results:

\[
\begin{align*}
Q_{S_{B,F}} &= 13.07 + .07 \left( \frac{P_{B,F}}{FC} \right)_{t=0} + \frac{5}{\xi=1,\ell} \left( \frac{P_{B,F}}{FC} \right)_{t-\ell} \\
&= -.06 \text{ PROD}_F - .07 \text{ HERD} \\
(3.30) (3.12) (6.2) (0.52) (0.08)
\end{align*}
\]

Range: 1956-73

\[
R^2 = .93 \quad \text{S.E.} = .05 \quad \sum_{\xi=1}^{5} \beta_{F,\xi} = .14 \quad D.W. = 1.47 \quad \hat{\rho} = .95 \quad r = 2
\]

¹ The critical range of the D.W. statistic is between .75 and 2.02
at the 5% level. Thus, the D.W. of 1.15 in equation (6.1) is in the
region of indeterminancy. Strictly speaking, the D.W. statistic does not
have a rigorous foundation in a simultaneous equations system, but it has
the practical value of showing whether the residuals are correlated or not.
The estimated statistic may be slightly biased but is probably not
inconsistent.

² In principle one would want to use Fair's method [13] to correct
for serial correlation because the lagged endogenous regressors in this
equation must be treated as endogenous variables (not predetermined).
However, the theoretically required number of instruments would exceed
the number of observations available for estimation so a modified proce-
dure was employed. The instrument list that was used was a) endogenous
variables lagged once, b) dependent variables lagged once, and c) all
exogenous variables. The lone exception from Fair's method was that all
exogenous variables lagged once were not used as instruments. The result-
ing estimates are not likely to be much different from what would have
been achieved under Fair's method because the additional instruments
would probably not have materially changed the corrected or "purged" esti-
mates of the current and lagged endogenous variables that are used in the
second stage regression.
These results are less encouraging in one respect because the productivity variable now takes the wrong sign although it is very insignificant. Yet a more important matter is that the lag coefficients now sum to a positive value although they are much less significant individually. The fifth period lag is the only marginally significant coefficient.

Although not shown, the pattern is again that of an inverted-U. Thus, equation (6.2) gives every indication that both the short- and long-run supply function is extremely inelastic.
A similar set of results for alternative specifications is shown in Table 6.1. In each case, when the equation is corrected for serial correlation, a very significant $\rho$ is obtained and most of the explanatory power of the equation is carried by the constant term.

It should also be noted that the results shown here do not include a variable for the farm wage rate. Preliminary regressions found that in the supply function at each market level, the wage rate consistently entered with the wrong sign (positive) and was often statistically significant. It may be true, especially for the farm supply equation, that wages are so highly dependent upon output that the regression is unable to isolate the effect that wages have as factor costs; rather the regression is a bastardized version of a demand for labor equation. Due to this problem, none of the supply function results reported here include a separate wage rate variable. One can remain confident that this exclusion is not a serious matter for two reasons; first, as noted in the earlier chapters on market structure, raw materials, not wages, are by far the largest cost element for producers; and second wages, at least at the slaughter and retail levels, are more important as they affect marketing margins.

Farm Demand

Demand for beef at the farm level is derived from the retail demand for beef function. A typical result for this equation is

---

1 I thank M.A. Adelman for suggesting this explanation to me.
Table 6.1  Alternative Regression Results for Farm Supply:

\[ Q_{S,B,F,t} = \alpha_0 + \beta_{F,0} \left( \frac{P_{B,F}}{FC} \right)_{t=0} + \frac{k_F}{\Sigma_{i=1}^{l} \beta_{F,i}} \left( \frac{P_{B,F}}{FC} \right)_{t-l} + a_2 \text{PROD}_{F,t} + a_3 \text{HERD}_t \]

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Estimated Coefficients</th>
<th>Summary Statistics$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\hat{\alpha}_0$</td>
<td>$\hat{\beta}_{F,0}$</td>
</tr>
<tr>
<td>(6.3)</td>
<td>.26 (.60)</td>
<td>.10 (.20)</td>
</tr>
<tr>
<td>(6.4)</td>
<td>11.72 (.32)</td>
<td>.01 (.12)</td>
</tr>
<tr>
<td>(6.5)$^2/ ,$</td>
<td>4.68 (.23)</td>
<td>-.003 (.47)</td>
</tr>
<tr>
<td>(6.6)$^2/ ,$</td>
<td>12.97 (.22)</td>
<td>.03 (.19)</td>
</tr>
</tbody>
</table>

$^1/ \,$ See explanation of summary statistics in a preceding footnote.

$^2/ \,$ The price ratio used in this equation was $\frac{P_{B,F}}{PCORN}$ in place of $\frac{P_{B,F}}{FC}$ .

See Appendix 1 for definitions of variables.
The demand price elasticity is statistically significant from zero at better than the .01 level indicating that the farm demand function is approximately unit elastic.\(^1\) The weighted average, retail chicken–pork price, \(P_{CP,R}\), enters with the theoretically incorrect sign and is statistically different from zero. This is a somewhat troublesome result which persisted in many of the alternate regressions, although in all but one case the coefficient was not different from zero.\(^2\) The income elasticity is positive, of a reasonable magnitude and is statistically significant at better than the .01 level. The D.W. statistic is again in the inconclusive range, but re-running the regression with a correction for autocorrelation did not alter the results and \(\rho\) was not significantly different from zero (see equation (6.8) in Table 6.2).

In the previous chapter, the derivation of the farm demand function also revealed that an index of marketing costs, \(I\), should theoretically

\[ QD_{BF} = -8.04 - 1.02 P_{BF} - .41 P_{CP,R} + .58 Y \]  
\[ (6.7) \]
\[ (.74) (.16) (.14) (.09) \]

Range: 1950-73 \[ R^2 = .88 \] \[ S.E. = .05 \] \[ D.W. = 1.55 \]

\(^1\)This result is somewhat different from others in the literature and is discussed in more detail in a following summary section.

\(^2\)A number of other econometric studies in the literature have also obtained fairly poor results for cross-price elasticities, see Freebairn and Rausser [3], and Hayenga and Hacklander [7]. Although the pork–chicken price coefficient is negative and significant this is not necessarily evidence of complementarity as others have argued [7], but may simply be a reflection of measurement error.
have an effect on demand. Experiments with different proxies for a shift in the derived supply schedule yielded mixed results. As shown in equations (6.9) and (6.10) of Table 6.2, the slaughter level wage, $W_R$, never takes the correct sign. However, a productivity variable for either the slaughter or retail level does take the correct sign, but reduces the effect of the income variable, as in equations (6.11) and (6.12).

**Estimated Equations for Slaughter Level**

**Slaughter Supply**

Attempts to model supply response at the slaughter level were more successful than at the farm level. A typical set of results was

$$Q_{S,t} = 2.34 - .93 \left( \frac{P_{B,S}}{P_{B,F}} \right) + \sum_{i=1}^{5} \beta_{S,i} \left( \frac{P_{B,S}}{P_{B,F}} \right)_{t-i} + 1.56 \text{PROD}_S$$

(6.13) (.48)

Range: 1955-73 $\quad R^2 = .97 \quad S.E. = .04$

$$\sum_{i=1}^{5} \beta_{S,i} = 1.56 \quad D.W. = 1.98 \quad r = 2$$

(1.11)

In equation (6.13) the short-run price elasticity is initially quite inelastic with a value of -.93, but as shown in Figure 6.2 the reaction coefficients turn strongly positive immediately. The second period lag is the one in which the strongest effect occurs. The long-run supply price elasticity is .64. Also note that the coefficient on productivity takes the correct sign and is statistically significant at better than .01 level, but seems to be of a slightly too great a magnitude.
Table 6.2  Alternative Regression Results for Farm Demand:

\[ Q_{D,B,F} = c_0 + c_1 P_{B,F} + c_2 P_{CP,R} + c_3 Y + c_4 I1 + c_5 I2 \]

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Estimated Coefficients [ \hat{c}_0, \hat{c}_1, \hat{c}_2, \hat{c}_3, \hat{c}_4, \hat{c}_5 ]</th>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range, ( R^2 ), S.E., D.W., ( \hat{\rho} )</td>
<td></td>
</tr>
<tr>
<td>(6.8)</td>
<td>(-7.96, -1.02, -0.45, 0.56)</td>
<td>1951-73, 0.87, 0.05, 1.54, 0.09 ( (0.21) )</td>
</tr>
<tr>
<td>(6.9)1,2/</td>
<td>(-7.89, -0.88, -0.12, 0.77, 0.28, -0.37)</td>
<td>1950-73, 0.90, 0.05, 1.35</td>
</tr>
<tr>
<td>(6.10)1,3/</td>
<td>(-4.52, -0.40, 0.38, 0.23, 1.20, -0.20)</td>
<td>1951-73, 0.92, 0.04, 1.70, 0.89 ( (0.09) )</td>
</tr>
<tr>
<td>(6.11)3/</td>
<td>(-5.55, -0.94, -0.11, -0.14, 0.78)</td>
<td>1951-73, 0.89, 0.05, 1.67, 0.22 ( (0.20) )</td>
</tr>
<tr>
<td>(6.12)2/</td>
<td>(-5.97, -0.86, -0.34, 0.16, 0.34)</td>
<td>1951-73, 0.87, 0.05, 1.43, 0.40 ( (0.19) )</td>
</tr>
</tbody>
</table>

1/ In this equation I1 is proxied by \( W_{RS} \) so the expectation would be that \( \hat{c}_4 < 0 \).
2/ In this equation I2 is proxied by \( \text{PROD}_{S} \) so the expectation would be that \( \hat{c}_5 > 0 \).
3/ In this equation I2 is proxied by \( \text{PROD}_{R} \) so the expectation would be that \( \hat{c}_5 > 0 \).
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Estimated Coefficient—$\hat{\beta}_{S,t}$ (S.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-0</td>
<td>-0.93 (.39)</td>
</tr>
<tr>
<td>t-1</td>
<td>0.46 (.83)</td>
</tr>
<tr>
<td>t-2</td>
<td>0.52 (.25)</td>
</tr>
<tr>
<td>t-3</td>
<td>0.44 (.46)</td>
</tr>
<tr>
<td>t-4</td>
<td>0.24 (.44)</td>
</tr>
<tr>
<td>t-5</td>
<td>-0.09 (.78)</td>
</tr>
</tbody>
</table>

Supply Elasticities

- $e_{SR} = -0.93$
- $e_{LR} = 0.64$

Figure 6.2. Plot of Lag Coefficients for Equation (6.13).
Alternative regression results are provided in Table 6.3. Equation (6.14), identical to equation (6.13) in all respects except for an estimate of $p$, allows one to reject a hypothesis of any autocorrelation. Examination of equations (6.14), (6.15), and (6.16), which vary only in terms of the degree of the polynomial, shows that short-run elasticities can change by as much as 25 percent and long-run by about 40 percent depending on whether the regression was estimated as a 2nd, 3rd, or 4th order polynomial. Even though there is this uncertainty about the precise value of the short- and long-run supply price elasticities there is little doubt that $e_{sr}$ is negative, like the primary supply function at the farm level, and that $e_{lr}$ is positive, most likely ranging between .6 and .9.

These results are fundamentally different from those at the farm level. Because packers are not saddled like farmers with the large fixed costs of a cattle herd, the packing industry can respond much faster to changes in relative prices. Thus, it is not surprising to find that the shape of the lag coefficients in Figure 6.2 is quite a bit different than in the preceding figure.

**Slaughter Demand**

Results for derived demand at the slaughter level were quite similar to what was obtained for farm level demand. A basic equation was

$$ Q_{DB,S} = -8.58 - .93 P_{B,S} - .08 P_{CP,R} + .67 Y $$

$$ (6.18) $$

| Range: 1950-73 | $R^2 = .98$ | S.E. = .03 | D.W. = 1.65 |
Table 6.3 Alternative Regression Results for Slaughter Supply:

\[ Q_{BS,t} = d_0 + \beta_{S,0} \left( \frac{P_{BS}}{P_{BF}} \right) + \sum_{\ell=1}^{k_S} \beta_{S,\ell} \left( \frac{P_{BS}}{P_{BF}} \right)_{t-\ell} + d_2 \text{PROD}_S \]

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Estimated Coefficients</th>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \hat{d}_0 )</td>
<td>( \hat{\beta}_{S,0} )</td>
</tr>
<tr>
<td>(6.14)</td>
<td>1.90 (2.54)</td>
<td>-1.14 (.42)</td>
</tr>
<tr>
<td>(6.15)</td>
<td>2.35 (1.54)</td>
<td>-1.47 (.30)</td>
</tr>
<tr>
<td>(6.16)</td>
<td>2.64 (1.71)</td>
<td>-1.44 (.31)</td>
</tr>
<tr>
<td>(6.17)</td>
<td>1.28 (1.43)</td>
<td>-1.04 (.30)</td>
</tr>
</tbody>
</table>
Again it is found that the demand function is approximately unit elastic, i.e., one could not reject the hypothesis that the own-price coefficient is equal to 1.00. The income elasticity is significantly different from zero and of a reasonable magnitude. The coefficient on the substitute price variable, $P_{CP,R}$, is negative but is more acceptable than in equation (6.7). Those studies of beef demand which have obtained substitute price elasticities with the theoretically correct sign have found them to be very close to zero and usually less than +.10.¹

In the case of equation (6.18), one could not reject the hypothesis that the coefficient on $P_{CP,R}$ is equal to +.07.

Alternative forms are given in Table 6.4. Correcting equation (6.18) for serial correlation has no appreciable effect, since (6.19) is nearly identical. Again it is found that indexes of marketing costs have little influence on derived demand, as in equation (6.20), and when there is some significant influence as with $WR_R$ it runs in the wrong direction and induces serial correlation.

**Estimated Equations for Retail Level**

**Retail Supply**

Representative results from estimating a retail supply of beef function were

¹See for example Brandow [2] and Hassan and Katz [6].
Table 6.4  
Alternative Regression Results for Slaughter Demand:

\[ \text{QD}_{B,S} = \hat{g}_0 + \hat{g}_1 \text{P}_{B,S} + \hat{g}_2 \text{P}_{CP,R} + \hat{g}_3 \text{Y} + \hat{g}_4 I_1 + \hat{g}_5 I_2 \]

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Estimated Coefficients</th>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \hat{g}_0 )</td>
<td>( \hat{g}_1 )</td>
</tr>
<tr>
<td>(6.19)</td>
<td>-8.46</td>
<td>-.91</td>
</tr>
<tr>
<td></td>
<td>( .43)</td>
<td>(.09)</td>
</tr>
<tr>
<td>(6.20)(1-2)</td>
<td>-8.58</td>
<td>-.78</td>
</tr>
<tr>
<td></td>
<td>(2.18)</td>
<td>(.11)</td>
</tr>
<tr>
<td>(6.21)(1-2)</td>
<td>-8.49</td>
<td>-.91</td>
</tr>
<tr>
<td></td>
<td>( .87)</td>
<td>(.10)</td>
</tr>
</tbody>
</table>

1/ In this equation \( I_1 \) is proxied by \( \text{WR}_R \) so the expectation would be that \( \hat{g}_4 < 0 \).

2/ In this equation \( I_2 \) is proxied by \( \text{PROD}_R \) so the expectation would be that \( \hat{g}_5 > 0 \).
\[ QS_{B,R} = 4.60 - 0.44 \left( \frac{P_{B,R}}{P_{B,S}} \right) + 5 \left( \frac{P_{B,R}}{R_{B,S}} \right) t=0 + \sum_{t=1}^{5} \beta_{R,t} \left( \frac{P_{B,R}}{R_{B,S}} \right) t-\tau + 1.01 \text{PROD}_{R} \quad (6.22) \]

Range: 1955-73 \quad R^2 = .99 \quad \text{S.E.} = .02

\[ \sum_{t=1}^{5} \beta_{R,t} = .94 \quad \text{D.W.} = 1.71 \quad r = 3 \]

In this equation the short-run price elasticity, \( e_{sr} \), is somewhat backward bending similar to the slaughter supply function, but here the coefficient for \( t=0 \) is not significantly different from zero at the .05 level. Figure 6.3, however, shows that the first lagged coefficient is indeed negative and statistically significant from zero after which the schedule turns strongly positive. The largest positive supply response comes in the fourth lagged period. The long-run elasticity, \( e_{lr} \), is +.50 which is similar to the result for the slaughter supply equation. The coefficient on the productivity variable in equation (6.22) is also acceptable, as it is significantly different from zero at better than the .01 level.

Alternative regressions in Table 6.5 reveal that the results in equation (6.22) are quite robust. Correcting for autocorrelation (in equation (6.23), varying the degree of the polynomial (equations (6.24) and (6.25)) or the length of the lag (equation (6.26)), all had but little effect on the basic results.

Notice that in Figure 6.3, the shape of the lag coefficients is similar to what was observed at the slaughter level, but that the period of the highest positive supply response occurs one or two years later.
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Estimated Coefficient-- (S.E.)</th>
<th>R,</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-0</td>
<td>-.44 (.29)</td>
<td></td>
</tr>
<tr>
<td>t-1</td>
<td>-.59 (.21)</td>
<td></td>
</tr>
<tr>
<td>t-2</td>
<td>-.05 (.21)</td>
<td></td>
</tr>
<tr>
<td>t-3</td>
<td>.57 (.19)</td>
<td></td>
</tr>
<tr>
<td>t-4</td>
<td>.81 (.22)</td>
<td></td>
</tr>
<tr>
<td>t-5</td>
<td>.20 (.27)</td>
<td></td>
</tr>
</tbody>
</table>

**Supply Elasticities**

\[ e_{SR} = -.44 \]

\[ e_{LR} = .50 \]

Figure 6.3. Plot of Lag Coefficients for Equation (6.22).
Table 6.5 Alternative Regression Results for Retail Supply:

\[ QS_{B,R,t} = h_0 + \beta_{R,0} \left( \frac{P_{B,R}}{P_{B,S}} \right)_{t=0} + \sum_{\ell=1}^{k_R} \beta_{R,\ell} \left( \frac{P_{B,R}}{P_{B,S}} \right)_{t-\ell}^\ell + h_2 \text{PROD}_R \]

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Estimated Coefficients</th>
<th>Summary Statistics</th>
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<tbody>
<tr>
<td></td>
<td>( \hat{h}_0 )</td>
<td>( \hat{\beta}_{R,0} )</td>
</tr>
<tr>
<td>(6.23)</td>
<td>4.72 (.29)</td>
<td>-0.44 (.29)</td>
</tr>
<tr>
<td>(6.24)</td>
<td>4.52 (.27)</td>
<td>-0.52 (.30)</td>
</tr>
<tr>
<td>(6.25)</td>
<td>4.59 (.25)</td>
<td>-0.53 (.29)</td>
</tr>
<tr>
<td>(6.26)</td>
<td>4.44 (.26)</td>
<td>-0.36 (.28)</td>
</tr>
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</table>
at the retail level. In general, this pattern suggests that retailers also are able to adjust much quicker than farmers to shifts in relative prices.

Retail Demand

The primary demand function for beef is at the retail level, and the results were quite comparable with those of the derived demand functions reported above. A basic relationship was:

\[ QD_{BR} = -9.40 - .92 P_{BR} - .23 P_{CR} + .80 Y \]

\( R = .97 \) S.E. = .03 D.W. = 1.69

The retail demand schedule is also approximately of unitary elasticity with respect to own-price, and the coefficient is strongly significant. The substitute price coefficient again takes the wrong sign. The income elasticity is strongly significantly different from zero and of a slightly greater magnitude than at the farm or slaughter levels. Re-running equation (6.27) with a correction for serial correlation yielded a \( \rho \) equal to .13 with a standard error of (.21) so any possibility for serial correlation was rejected.

Estimated Equations for Marketing Margins

Farm-Carcass Margin

As was noted in the last chapter which developed the theory of price spread determination, the farm-carcass marketing margin measures the cost of marketing cattle, slaughtering the animal, and transporting the dressed beef carcass to the city where it is consumed. A preferred regression was
The wage rate has the theoretically correct sign but is only significant from zero at approximately the .11 level. The coefficient on the rail rate for meats, RRM, is significantly different from zero at better than the .01 level thereby suggesting that variability in transportation costs plays a larger role than wage costs in explaining variation in the farm-carcass margin. This is a mildly puzzling result because labor expenses have usually accounted for about one-third more of this margin than transport charges [12]. The coefficient on the productivity variable is highly significant underscoring the strong effect that rightward shifts in the slaughter supply function have in reducing the farm-carcass margin.\(^1\) The sign on the quantity variable is positive and significantly different from zero at the .05 level. It should be recalled from the specification of the margin in the previous chapter that the effect of the quantity variable was somewhat ambiguous, standing for either economies of scale or for short-run constraints on capacity. The positive sign on \(Q_S B_S\) may indicate that capacity utilization in meatpacking was relatively high over this period so that increases in shipments forced up industry average costs and widened margins.

The derivation of the margin functions also stressed the point that margins will change not only in response to changes in marketing industry

\(^1\)See Figure 5.1 and accompanying discussion in previous chapter for how this effect goes through.
costs but also in response to shifts in the underlying schedules of primary supply and primary demand. Results from including measures of these effects are shown in Table 6.6. The coefficient on income, Y, takes the correct sign in each case and is quite significant in both equations (6.30) and (6.31), but overall including Y tends to reduce the effect of the wage rate on the margin. The farm cost index, FC, takes the correct sign but is not significantly different from zero, thus indicating what little effect the farm sector has on the price spread. None of the equations reveal any problems with serial correlation.

**Carcass-Retail Margin**

The carcass-retail margin includes the gross margin for retailing and the cost of other marketing services including breaking carcasses, fabricating, wholesaling, and store-door delivery to retailers. A representative regression for this margin was

\[
M_{S,R} = 2.84 + 1.69 \, WR_R - .58 \, QS_{R,R} \quad (6.33)
\]

\[
(2.16) \quad (.38) \quad (.26)
\]

Range: 1950-73 \quad R^2 = .87 \quad S.E. = .07 \quad D.W. = 2.06

In contrast to the farm-carcass margin, the wage rate here is a major factor; the coefficient on WR is significantly different from zero at the .001 level. One explanation for the relatively better performance of the wage rate in equation (6.33) compared to (6.28) is that labor costs account for more than one-half of the carcass-retail margin whereas they are only one-quarter of the total farm-carcass margin [12]. The quantity variable in equation (6.33) takes a negative sign more in keeping
Table 6.6  Alternative Regression Results for Farm-Carcass Margin:

\[ M_{F,S} = m_0 + m_1 Y + m_2 W_R + m_3 F_C + m_4 Q_S + m_5 P_O D + m_6 R R M \]

<table>
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<tr>
<th>Equation Number</th>
<th>Estimated Coefficient</th>
<th>Summary Statistics</th>
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<tr>
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<td>(6.29)</td>
<td>-1.45 (2.06)</td>
<td>-.60 (.64)</td>
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<tr>
<td>(6.30)</td>
<td>-1.36 (1.74)</td>
<td>-1.06 (.36)</td>
</tr>
<tr>
<td>(6.31)</td>
<td>.76 (1.60)</td>
<td>-1.56 (.22)</td>
</tr>
<tr>
<td>(6.32)</td>
<td>-1.24 (1.88)</td>
<td>-.55 (.60)</td>
</tr>
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with prior expectations, and the coefficient is significantly different from zero at the .05 level. This result may reflect that there was some unused capacity in retailing during this period or that there were possibly some unrealized returns to scale. Whatever the true effect of the quantity variable, it does not contribute as much as the wage rate to the explanation of variation in the margin.

Some alternative forms are shown in Table 6.7. Two variables in equation (6.34) which in theory should have an effect on the carcass-retail margin are productivity, PROD, and the cost of cardboard containers, PCONT; while both take the theoretically correct signs neither is significantly different from zero. In general the alternative regressions in Table 6.7 show that there is no evidence of autocorrelation and that the wage rate is consistently the major determinant of variation in the carcass-retail margin. Except for the quantity variable which is typically of marginal statistical significance, none of the other explanatory variables plays much of a role.

It will be recalled from Chapter 5 that the two marketing margins were derived as reduced form equations from the six structural equations. This means that the margins did not actually have to be separately estimated econometrically because the parameters of the margin equations are uniquely determined by the parameters of the underlying supply and demand equations. As a consistency check the reduced form was solved for in terms of the two marketing margins, and the estimated coefficients from the structural equations were inserted in the reduced form. Obviously, not all of the predetermined variables in the
six structural equations appeared as exogenous regressors in the final form of the estimated margin equations. To have done this would have quickly exhausted all of the degrees of freedom. However, for those variables for which a comparison could be made, the estimated coefficients reported in equations (6.28) - (6.37) were quite close to the coefficients calculated from the reduced form. Only one coefficient (the one on FC in the carcass-retail margin) did not take the theoretically correct sign and this coefficient was approximately equal to zero.

Summary of Preferred Results

The preceding sections of this chapter have presented detailed estimates of the parameters of an econometric beef model. The results allow one to evaluate the hypotheses that were formulated in the previous chapter on the model specification. Recall that a primary aim of this model is to gain a better understanding of the process of beef price determination by analyzing the elasticities of supply and demand at each major market level. Also the related issue of margin behavior is to be examined because it is the intersection of
Table 6.7  Alternative Regression Results for Carcass-Retail Margin:

\[ M_{S,R} = n_0 + n_1 Y + n_2 W_{R} + n_3 FC + n_4 Q_{S,R} + n_5 PROD_{R} + n_6 PCONT \]

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Estimated Coefficients</th>
<th>Summary Statistics</th>
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<td></td>
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<td>2.83</td>
<td>1.77</td>
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<td></td>
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<td>(6.35)</td>
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<td>3.75</td>
<td>2.08</td>
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<tr>
<td></td>
<td>(2.30)</td>
<td>(.49)</td>
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supply and demand in each market—farm, slaughter, and retail—which determines, not only prices, but marketing margins, as well.

Table 6.8 offers a summary of some representative elasticity estimates that were obtained from estimating the econometric model. Although the farm supply equation proved difficult to estimate, in general the results for the supply side indicate that supply at all market levels is extremely inelastic in the short-run. In fact, there is substantial evidence that, due to the particular economic characteristics of cattle raising, all of the supply functions are backward bending in the short-run. Also, the persistence of "backward bending-ness" appears to be more pronounced at the farm level as compared to the packer or retail levels. This fundamental difference in industry reaction to changes in relative prices is vividly portrayed in the separate plots of the lag coefficients shown in Figures 6.1, 6.2, and 6.3. The figures show that the peak positive supply response occurs in the second, third and fourth lagged periods at the slaughter and retail levels while at the farm level it takes a full five years to elicit a strong positive response.

These general results lend support to one of the central ideas of this thesis: that each separate market, in and of itself, is important in the process of beef price determination. Thus, it would be inappropriate to formulate a model solely in terms of farm supply (or retail demand, for that matter) because the packing and retailing industries are both key segments of the overall framework.

The farm supply price elasticities reported in Table 6.8 are similar in many respects to the estimates reported in the literature as summarized
Table 6.8 Summary of Elasticity Estimates Obtained from Econometric Beef Model.

<table>
<thead>
<tr>
<th>Elasticity</th>
<th>Estimated Value</th>
</tr>
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<tbody>
<tr>
<td>Farm Supply: Price</td>
<td>0.07&lt;sup&gt;a&lt;/sup&gt;; 0.21&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Slaughter Supply: Price</td>
<td>-0.93&lt;sup&gt;a&lt;/sup&gt;; 0.64&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Retail Supply: Price</td>
<td>-0.44&lt;sup&gt;a&lt;/sup&gt;; 0.50&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Farm Demand:
- Price: -1.02
- Income: 0.58

Slaughter Demand:
- Price: -0.93
- Income: 0.67

Retail Demand:
- Price: -0.92
- Income: 3.80

<sup>a</sup> Short-run
<sup>b</sup> Long-run
in Table 5.1 of the previous chapter. It is difficult to make a
strict comparison however, because all but one of the earlier studies
fail to account for the dynamic properties of the supply function.
Nonetheless all of the studies cited in the literature survey found,
as with these results, that supply at the farm level is quite price
inelastic. Unfortunately, there are no studies in the literature
with which one could compare the results for the slaughter and
retail supply functions. One can remain confident that these "new"
results are reliable for three reasons: 1) the coefficients are
different from zero at a high level of statistical significance,
2) similar results are obtained when the length of the lag or the
degree of the polynomial is varied, and 3) there are no apparent
problems with serial correlation.

On the demand side, the income elasticities are quite similar
to previous results in the literature (see Table 5.1). Table 6.8
also shows that the own-price elasticities are quite close to one
another and all are nearly equal to unity. These results both
conform with and stand in direct opposition to prior results in the
literature. (See Table 5.1). In terms of conformity, most studies
of retail beef consumption have found the own-price elasticity to
be between -0.8 and -1.0. Thus, the present results confirm what
has been well-known for some time, i.e., that a given increase in
the retail price of beef will trigger an approximately proportionate
decrease in the quantity demanded at retail. However, the results
in Table 6.8 shed new light on what heretofore has been assumed to
be an empirical law: that the demand for beef is less and less elastic as one moves upstream in the marketing chain from the retail to the farm levels.

What previous empirical researchers have failed to recognize is that demand at the farm level (or the slaughter level) while being derived from retail demand also depends critically upon the elasticity of substitution between (1) the farm product, and (2) all other processing and distribution factors. For example, the relationship between farm level demand elasticity, $e_F$, and retail level elasticity, $e_R$, can be shown to depend on both the elasticity of substitution, $\sigma$, and the relative shares of the final product's total costs made up by beef, $v_B$, and by all other processing-distributing factors, $v_A$, where $v_A + v_B = 1$, as in

$$e_F = - (v_A \sigma + v_B e_R)$$  \hspace{1cm} (6.38)

Equation (6.38) clearly shows that if one assumes that the supply of factor A is perfectly elastic to the industry and that inputs are combined in fixed proportions, i.e., $\sigma = 0$, then it follows directly that $e_F = -v_B e_R$. Since $v_B$ must be less than one by definition, the farm level elasticity of demand must always be less than the retail level elasticity. This simple relationship explains why a number of studies, i.e., [2], [5], [8], [9], and [13],

1This relationship is formally derived in Allen [1, pp. 372-74], and is discussed in both Robinson [11, pp. 253-64] and Nicholls [10, pp. 40-50]. Also Gardner [4, pp. 404-5] develops a slightly more general approach, but the results are essentially the same.
which have employed the assumption of fixed proportions have found that the farm level demand for beef function was less elastic than the respective retail level function.

A more balanced approach is simply to run the demand regressions without any a priori restrictions on the value of $\sigma$. This is what was done here and it thereby explains why the results for the demand price elasticities are different from those in the literature. As a test of these results, estimates of $e_F$ and $e_R$ from Table 6.8 were inserted into equation (6.38) along with approximate values for the shares of total cost, $v_A = 0.4$ and $v_B = 0.6$. It was found by this method that the implied value of $\sigma$, the elasticity of substitution between farm beef inputs and processing-distributing inputs, was 3.9. This is probably an upper bound on the value of $\sigma$. A more reasonable value of $\sigma = 1.8$ was obtained by use of the crude procedure outlined by Gardner [4, p. 406]. While neither estimate of $\sigma$ should be taken as definitive because of the well known problems of

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1 In point of fact, the assumption of a perfectly elastic supply function for factor A may not be fulfilled. If this is the case then a more complicated formula like equation (21) in Gardner [4, p. 405] should be used in place of equation (6.38). The end result would be that $e_F$ could be at least as great if not greater than $e_R$, even in the fixed proportions case. This point was recognized early by Nicholls [10, p. 49] who discusses the implication of economies of scale in processing-distributing:

"If a proportionate reduction in the price of the farm product brings about an equal, or greater than, proportionate reduction in the processing and distributing costs (by increasing the industry's total volume of operations and so leading to external economies), the elasticity of demand for the farm product will be equal to, or greater than, the elasticity of demand for the final product."
obtaining efficient estimates of $\phi$, these results strongly suggest that the fixed proportions assumption, so often employed in the beef literature, is untenable. There must be some finite degree of substitution possible between beef inputs and processing-distributing factors.

---

\footnote{Nerlove's major finding in a survey of various estimates of the elasticity of substitution between capital and labor is one of diversity: "Even slight variations in the period or concepts tend to produce drastically different estimates of the elasticity." [14, p.58].}
References


Appendix 3. Definitions and Sources of Data Used in the Econometric Analysis.

Variables

FC  prices paid by farmers for feed, (1967 = 100), (6).

HERD  number of cattle and calves on farms at the beginning of year, (millions of head), (6).

M_F,S  farm-carcass price spread, calculated as difference between farm value and carcass value, i.e., \( P_{B,S}^* - P_{B,F}^* \) deflated, (1972 $/retail equivalent pound), (9).

M_S,R  carcass-retail price spread, calculated as difference between retail price and carcass value, i.e., \( P_{B,R}^* - P_{B,S}^* \) deflated, (1972 $/retail equivalent pound), (9).

P_{B,F}  live animal price of Choice grade steers at 7 leading public stockyards and average of quotations to California feeders and ranchers, deflated, (1972 $/pound), (7).

P_{B,F}^*  net farm value obtained by subtracting a byproduct allowance from gross farm value. The gross farm value represents payment to farmer for quantity of Choice grade beef cattle equivalent to 1 pound of retail cuts. The farm product equivalent of 2.12 was used prior to 1952; it was increased gradually to 2.28 for 1962 and later years, deflated, (1972 $/retail equivalent pound), (9).

P_{B,F}  beef steer-corn price ratio, Omaha basis. Bushels of No. 2 yellow corn equivalent in value to 100 pounds of slaughter steers, all grades, sold out of first hands, (7).

PCORN  average retail price of beef, for over 20 retail cuts of beef, Choice grade, calculated from BLS data and prices reported by 40 retail chain divisions, deflated, (1972 $/pound), (9).

P_{B,S}  weighted average of price quotations for primarily 600-700 pound carlots of steer carcasses, Choice grade, at Chicago and West Coast markets, deflated, (1972 $/pound), (7).
\( P_{B,S} \) wholesale value of quantity of Choic grade carcass beef equivalent to 1 pound of retail cuts. A wholesale carcass equivalent of 1.32 was used prior to 1952; it was increased gradually to 1.41 for 1962 and later years, deflated, (1972 $/retail equivalent pound), (9).

PCONT wholesale price index for paper boxes and shipping containers, (1967 = 100), (4).

PCORN average price of corn received by farmers, deflated, (1972 $/bushel), (6).

\( P_{C,R} \) weighted average chicken-pork retail price, computed from \( P_{C,R} \) and \( P_{P,R} \), deflated, (1972 $/pound). 

\( P_{C,R} \) retail price of broilers, whole or cut-up, in retail stores in urban areas, deflated, (1972 $/pound), (8).

POP U.S. population, (thousands of persons), (5).

\( P_{P,R} \) retail price of pork, deflated, (1972 $/pound), (9).

PRODF index of farm output per unit of input, (1967 = 100), (6).

PRODR index of output per hour of all persons in retail food stores, (1967 = 100), (3).

PRODS index of output per man-hour of all persons in all-manufacturing, (1967 = 100), (6).

\( Q_{D,B,F} \) per capita commercial cattle and calf slaughter, live weight, (pounds/person), (7).

\( Q_{D,B,R} \) per capita civilian consumption of beef, retail weight, (pounds/person), (7).

\( Q_{D,B,S} \) per capita commercial production of beef, carcass weight, (pounds/person), (7).

\( Q_{S,B,F} \) total commercial beef cattle and calf slaughter, live weight, (million pounds), (7).

\( Q_{S,B,R} \) total civilian consumption of beef, retail weight, (million pounds), (7).

\( Q_{S,B,S} \) total commercial production of beef, carcass weight, (million pounds), (7).
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Reference</th>
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<tr>
<td>RRM</td>
<td>index of railroad freight rates for meats, ((1967 = 100)), (6).</td>
<td></td>
</tr>
<tr>
<td>WR_{F}</td>
<td>average hourly earnings for farm workers without board or room, deflated, ((1972 $/hour)), (6).</td>
<td></td>
</tr>
<tr>
<td>WR_{R}</td>
<td>average hourly earnings for non-supervisory workers in retail food stores, deflated, ((1972 $/hour)), (1).</td>
<td></td>
</tr>
<tr>
<td>WR_{S}</td>
<td>average hourly earnings for production workers in meatpacking plants, deflated, ((1972 $/hour)), (1).</td>
<td></td>
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<tr>
<td>Y</td>
<td>per capita disposable personal income, deflated, ((1972 $/person)), (5).</td>
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Sources


Introduction

Up to this point purely competitive conditions have been assumed to hold in each market in which beef prices and quantities are determined. A recent legal case presents an interesting problem in law and economics, and as such the case offers an opportunity to test certain propositions within the context of the econometric model. This chapter first summarizes the key arguments and results of this legal case, and then poses the central economic issues in the case in terms of a testable hypothesis. A final section offers some econometric results.

In 1968 the Bray case was brought by a small number of cattlemen against the three largest retail grocery chains in the U.S. for violation of Section 1 of the Sherman Anti-Trust Act.1 Plaintiffs claimed that Safeway Stores, A & P, and The Kroger Company in combination with twelve other of the nation's largest food retailers conspired to and did control the prices which the plaintiff cattlemen received for their beef. Safeway and Kroger settled out of court, paying minimal damages and admitting no guilt, thereby leaving A & P as the sole defendant. After a six week trial the jury decided in favor of the plaintiffs in the amount of $10.9 million which under the antitrust statutes was trebled to arrive at A & P's total liability of $32.7 million. A & P was also required to pay plaintiffs attorney's fees of $3.2 million.

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Some of the particular claims of the plaintiffs included:

1. The price fixing conspiracy was organized and carried out through a trade association, the National Association of Food Chains (NAFC), an organization made up of the largest retail food chains in the U.S.; independents and small grocers were not eligible for membership,

2. The defendant and co-conspirators had the opportunity to meet and did in fact discuss beef prices at NAFC meetings,  

3. A trade publication, the "Yellow Sheet," was a means by which the conspirators communicated to one another information on prices paid for quantities of beef in the wholesale (or packer) market,

4. The centralized buying systems of chains were a device for fixing prices,

5. The beef market was competitive until 1956 when the conspiracy began and prices received by farmers then began to drop in the face of rapidly increasing demand; concurrently the gross profit margin of the retail chains was sharply increasing,

6. A Court injunction terminated (or at least hampered) the conspiracy in 1971 and beef prices at the farm level then began to rise markedly.

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1 Chief Judge Oliver J. Carter ruled that, "(i)n a case such as this, where there does not exist an express price fixing agreement, the opportunity to discuss prices is of paramount interest.... The evidence presented by the plaintiffs not only demonstrated the existence of such an opportunity, but indicated that prices had in fact been discussed." [2, p. 857].
For their part, A & P made the following claims in their defense:

1. there was no evidence of a conspiracy, or of an agreement between conspirators, or of any consciously parallel action,

2. A & P accounted for only 7 to 8 percent of total grocery beef sales and an even lower proportion of total beef sales, thus they did not have the market power to fix prices, 1

3. rising retail margins during a period of fairly constant farm prices were due to increases in retail labor and distribution costs.

In calculating the size of the damage award, the jury decided that the plaintiffs would have received 20 cents more per pound if the conspiracy had not been in effect. The $10.9 million figure was calculated by multiplying the total number of pounds sold by each plaintiff by 20 cents.

A & P argued that the damages assessed by the jury were not supported by the evidence and that the size of the award was "monstrous."

The Court answered this charge with:

1 On this issue Judge Carter held that "(a)lthough it would be convenient if there existed a yardstick for courts to measure the market percentage necessary to control a particular market, the defendants blatant assertion that 7 to 8% is 'clearly' insufficient fails to account for the realities of the modern marketplace. If a market is diverse, a relatively low percentage of total sales may be able to assert sufficient influence to allow regulation of prices.... The question of relative market strength is thus essentially one for the jury." [2, p. 858].
"... if the damages were calculated according to reasonable evidentiary foundation, the mere size of the verdict will not prevent recovery."

"The 20 cent figure is undoubtedly an average; the plaintiffs are not, however required to prove damages with mathematical certainty."

"Defendant's control of the market made a more precise determination of damages impossible,

"The jury must 'make a just and reasonable estimate of the damage based upon relevant data, and render its verdict accordingly.'" [2, p. 864-5].

The case was settled on appeal and dismissed on August 5, 1975 [3]. A & P eventually paid approximately $9 million in damages.

Clearly the case centers around whether or not there was an oligosonistic (or buyers') conspiracy operative in the wholesale carcass market during the period 1956-71. Let us examine the economics of this case with reference to the concepts that have been developed in the earlier sections of this chapter.

There is only a meager treatment in the economics literature of the problem of the large buyer. Among theoretical studies, Robinson [11, p. 209-231] provides one of the earliest analyses and it was upon her work that Nicholls based his classic [9] published in 1941 on imperfectly competitive buying markets in agriculture. Many of the examples in Nicholls are taken from meatpacking. Handy and Padberg [4] deal with the interactions between food manufacturers and food

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1 Part of the exposition which follows is from Nicholls [9, p. 58-63] and also from Hirshleifer [5, p. 342-378] which is probably the most thorough modern textbook treatment of monopsony.
distributors depending on differences in market structure, but there is scant formal theorizing. Among empirical case studies, Adelman [1] and McKie [8] both provide numerous examples and analyses of how actual markets operate in which there are large buyers.

More general studies of buying power in terms of inter-industry comparisons have recently been offered. Porter [10] introduces a bifurcation of the product market into shopping and convenience goods as a means for explaining whether the manufacturer or distributor is more or less successful in imputing the rents which result from entry barriers. Lustgarten [7] directly addresses the matter of buying power and finds that when buyer concentration is high this tends to offset the ability of concentrated sellers to sell at prices in excess of marginal cost.

Analysis and Hypothesis Specification

In order to isolate the economic issues involved in the Bray case, let us make the following simplifying assumptions. First, the retail sector of the beef trade is a homogeneous buyer of carcass beef from the meatpacking industry; that is, retailers act as a single firm or monopsonist. Second, in the time frame under consideration all input factors used by retailers are fixed except for carcass beef, e.g., inputs of labor and capital are not allowed to vary. Third, all other sectors of the beef trade are assumed to be purely competitive, i.e., farmers and slaughterers are atomistic and also retailers are price
takers in their product market.¹

As the "retail firm" faces the factor market for carcasses, it chooses an amount of beef which maximizes its profits depending on the costs and returns of factor employment. The returns to the retailer from selling incremental units are defined as the value of marginal product, VMP, which is the price of retail beef cuts times the physical marginal product of beef carcasses. This is shown as the downward sloping schedule in Figure 7.1 and represents the retailer's derived demand schedule for carcass beef. The total cost to the retailer of buying carcasses is denoted as $TC = C \cdot Q$, and the supply curve of carcasses is the schedule of average factor cost, $AFC = TC/Q$. AFC gives the average amount that must be paid to buy any specified number of pounds of carcasses. The additional expense to the retail monopsonist in buying an incremental pound of carcass beef is the marginal factor cost, $MFC = \partial TC/\partial Q$. Both AFC and MFC are shown as upward sloping schedules in Figure 7.1.

Since by assumption, the retailer is the only firm buying carcasses it faces an upward sloping supply schedule for carcasses rather than the horizontal schedule faced by the competitive buyer. Thus, the monopsonist's decision to buy more or fewer pounds of beef drives the price up or down.

The "retail firm" will buy carcasses up to the point where the

¹ Assuming that retailers are also either monopolists or imperfectly competitive in their sales market introduces a further complication. This particular market structure was not part of the Bray allegation, but is discussed below.
Figure 7.1. Factor Price Determination Under Monopsony.
marginal revenue of an additional pound is just equal to the marginal expense incurred in buying that unit. This point of equality is at A in Figure 7.1. Accordingly, the firm will pay the factor price $C_0$ to elicit $Q_0$ pounds from the packing industry, as indicated by the height of the supply curve AFC at that point. In a competitive industry, the firm would face a horizontal factor supply schedule and would find $AFC = MFC$. In the Figure, point B would be the result obtained under competitive buying conditions; note that the factor cost, $C_1$, and the quantity purchased $Q_1$, are higher than what obtains under monopsony. ¹

What effect would a retail monopsonist have on marketing margins? In Chapter 5 the determination of margins under purely competitive conditions was derived (see Figure 5.1).

¹ Now suppose that the monopsonistic retailer also has monopoly power in its product market. In this case, the returns from using more carcasses in the production of retail cuts will be adversely affected by a downward sloping retail demand function. As more product is sold the price falls. For the monopolist, the incremental return to factor employment is not VMP but the incremental revenue obtainable from selling that marginal product. Define the marginal revenue product, $MRP$, as the product marginal revenue times physical marginal product. For competitive firms $MRP = VMP$, but for the monopolist $MRP$ lies below and falls faster than $VMP$. Since equilibrium in the factor market occurs at $MRP = MFC$, the monopolist will buy a lower quantity of carcasses than the pure competitor. For the firm that is both a monopsonist and a monopolist simultaneously lower factor prices and lower factor employment will result than under either simple monopoly or simple monopsony.
Contrary to that picture, a retailer monopsony would initially have the effect, ceteris paribus, of shifting downward the derived demand for carcass beef at the slaughter level.\(^1\) This is shown as a shift from \(D_S\) to \(D_S'\) in Figure 7.2. The meatpacking industry, purely competitive by assumption, would have no choice but to pass the lower prices they receive back to the farm level, thereby also shifting downward the "doubly-derived" farm demand schedule, i.e., \(D_F\) to \(D_F'\). From Figure 7.2 it is clear that the retail monopsonist would lower prices at the slaughter (from \(P_S^*\) to \(P_S'^*\)) and farm levels (\(P_F^*\) to \(P_F'^*\)), and raise price at the retail level (\(P_R^*\) to \(P_R'^*\)). Also quantity would be restricted (from \(Q_0\) to \(Q_1\)) and the carcass-retail margin raised from \((P_R^*-P_S^*)\) to \((P_R'^*-P_S'^*)\).\(^2\) The farm-carcass margin would remain unchanged.

This example of the retail sector as monopsonist is useful for expository purposes, but does not conform with the facts of the Bray case. The defendants and a dozen other large retailers were accused of being conspiring oligopsonists. In theory oligopsony, the problem of a few buyers, is quite different from the polar cases of monopsony or pure competition in buying. Precisely what output and price will be for one firm depends on the reactions of other firms to

\(^1\) This result retains the assumption used in Chapter 5 that supply schedules are positively sloped, linear, and parallel; that demand schedules are negatively sloped, linear, and parallel; and that the absolute values of all the slopes are equal.

\(^2\) Note that the increase in the margin also causes retail supply to shift from \(S_R\) to \(S_R'\).
Price Per Unit of Beef ($/retail pound)

Farm-Carcass Spread ($F_S$): $P_S^* - P_F^*$
Carcass-Retail Spread ($S_R$): $P_R^* - P_S^*$
Farm-Retail Spread ($F_R$): $P_R^* - P_F^*$

Figure 7.2. Beef Price Spread Determination Under Monopsony.
one's own buying policy. The dual problems of a few sellers or a few buyers are equally knotty with numerous possible solutions. If one assumes that there is perfect, formal collusion among the buyers then if the size of the collusive group is large with respect to the total market the result may be quite close to what would obtain under monopsony. However, if the collusive group is ineffective in exercising their power, and fails to recognize the circular interdependence among the few firms' buying policies then there is a range of indeterminacy concerning equilibrium price and output. ¹ Even if the conspirators are relatively successful, there will always be pressure from within for any individual firm to break from the ranks and to pay a slightly higher price to one's suppliers and gain higher profits and market share.

Given this treatment of the economic issues involved in the Bray case, let us now return to the question which began this chapter: how can one test the proposition that there was an oligopsonistic conspiracy operative in the wholesale carcass market during the period 1956-71. As a starting point, the assumption of pure competition will again be invoked. This permits the use of equation (5.28) as a vehicle for testing the effectiveness of the alleged oligopsony. The equation for the carcass-retail margin is reproduced here for convenience,

\[
M_{S,R} = n_1 + n_2 Y + n_3 WR + n_3 PCORN + n_4 QS_{B,R} + n_5 PROD_{R} + e
\]

(5.28)

¹ See discussion in Scherer for a variety of outcomes when powerful buyers face weak sellers [12, p. 249].
Recall that the carcass-retail margin measures the costs of retailing, fabricating, wholesaling, and in-city transporting of the beef product. Most of the margin is accounted for by wages which vary directly with the margin, but there are also retailer profits and other charges.

As was illustrated in Figure 7.2 a retail monopsonist or an effective group of oligopsonists would increase the margin over what it would normally be in a competitive market. The Bray plaintiffs claimed that the retailer conspiracy was operative during 1956-71; outside of this period an unfettered market was free to determine prices, quantities, and margins. In order to test the Bray allegation one would first estimate equation (5.28) over the conspiracy period, and compute the residual sum of squares calling them A. Then a second regression would be run over the entire sample period, 1949-73, thereby including both the "free market" and "conspiracy" periods. From this second regression the residual sum of squares would also be computed and called B. The test of the null hypothesis that the coefficients in the two regression equations are equal is given by the F-statistic,

\[ F = \frac{(B-A)/m}{A/(n-k)} \]

which is distributed as F with (m, n-k) degrees of freedom, where m is the number of years in the free market period, n is the number of years in the conspiracy period, and k is the number of parameters to be estimated.  

\[ 1 \]

This is the so-called Chow test and is described in Johnston [6, p. 206-207] and the references therein.
A Test of the Oligopsony Hypothesis

To perform the test, equation (6.33) was re-run but only over the alleged conspiracy period with the following results,

\[ M_{SR} = 6.36 + 2.21 W_{BR} - 1.00 Q_{SB,R} \]  
\[(7.1)\]

\[ (3.18) \quad (0.59) \quad (0.38) \]

Range: 1956-71 \[ R^2 = 0.70 \quad \text{S.E.} = 0.06 \quad D.W. = 2.46 \]

The relationship between the sum of the squared residuals in equations (6.33) and (7.1) is distributed as F. For the problem at hand the computed value of the F-statistic is 1.17 while the critical value at the 95% confidence level is 2.77. Thus the Chow test does not permit one to reject the null hypothesis that margin behavior was identical, and determined by the same economic forces, both within and outside the alleged conspiracy period.

A second, less formal means of testing this hypothesis is to take equation (7.1) and backcast and forecast it over the periods in which the conspiracy was supposedly inoperative. If the monopsonistic conspiracy were effective during the period 1956-71, then equation (7.1) should consistently over-predict when applied to earlier or later periods.

The results of this test are shown in Figure 7.3 where one can see that equation (7.1) tracks fairly accurately in the pre-conspiracy period, 1950-55. The only two years in which the equation misses badly are 1951, when it overpredicts, and 1953, when it underpredicts. In the post-conspiracy period, 1972-75, equation (7.1) consistently
underpredicts the actual carcass-retail margin, i.e., after the conspiracy supposedly ended, margins improved.¹ None of these results would allow one to reject the hypothesis that margins, while they may vary over time, were responding to the same set of economic forces over the entire period, 1950-75.

¹ The reason that equation (7.1) underpredicts so consistently in the later period is probably due to the relatively stronger rates of inflation experienced in the forecast versus the sample period. Because wage increases tend to lag behind price increases in an inflationary period, it is not surprising that the retail wage rate WR₁, might fail to track the level of the price spread.
Figure 7.3. Plot of Actual and Fitted Values of the Carcass-Retail Margin \( M_{s,r} \) from a Backcast and Forecast of Equation (7.1).
References


