AN ABSTRACT OF THE THESIS OF

David Wallace Norman for the M.S. in Agricultural Economics
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Title Economic Analysis of Beef Cattle Prices

Abstract approved

(Major professor)

The specific objectives of this study were to (1) assess the importance of the beef cattle industry in Oregon relative to the nation as a whole, and relative to the dairy industry in Oregon, (2) to compare annual and seasonal trends of prices and production in Oregon with the United States and (3) to derive price equations for slaughter, and stocker and feeder cattle in Oregon and the United States.

The first two objectives were investigated using straightforward analytical techniques such as simple regression and the ratio to moving average method. However, in spite of the lack of complexity in this part of the study, the results were considered to be of value as little work has been done in comparing Oregon with the national aggregate. As a general conclusion the beef cattle industry in Oregon, although still an insignificant contributor to the United States, appears to be progressing favorably especially when compared with the dairy industry within the state.

Considerable emphasis was placed upon the third objective,
In which two price equations were theoretically derived and empirically estimated using stepwise regression. The two price equations were concerned with prices at the farm level for slaughter, and feeder and stocker cattle.

The following results were obtained, the figures in parenthesis being t-ratios:

\[
Y = 19.41227 + 1.66456 X_1 + 0.01085 X_2 - 0.19481 X_3
\]
\[
(8.79735) \quad (6.45309) \quad (-11.41308)
\]

\[
R = 0.99352
\]

\[
R^2 = 0.98708
\]

\[
S_{yx} = 0.58486
\]

where:

\[X_1 = \text{by-product allowance in dollars per 100 pounds in real terms for choice steers.}\]

\[X_2 = \text{disposable income in dollars per capita, expressed in real terms.}\]

\[X_3 = \text{total liveweight in pounds of beef commercially slaughtered per capita.}\]

\[\hat{Y} = \text{annual price per 100 pounds received by United States farmers for slaughter beef in real terms.}\]

\[
\hat{Y} = 132.49251 + 0.0000063075 X_2 + 0.17069 X_4 +
\]
\[
(3.01575) \quad (1.57827)
\]
\[
8.39662 X_5 - 1.54999 X_6
\]
\[
(13.87748) \quad (-4.84093)
\]

\[R = 0.99632\]
\begin{align*}
R^2 &= 0.99263 \\
S_{yx} &= 3.70109
\end{align*}

where:

\begin{align*}
\hat{Y} &= \text{price per head of feeding and breeding cattle in the United States, expressed in real terms.} \\
X_2 &= \text{size of corn grain crop in 1,000 bushel units.} \\
X_4 &= \text{average weight in pounds per head of feeder steers of all weights.} \\
X_5 &= \text{price of slaughter beef per 100 pounds received by United States farmers in the current year and expressed in real terms.} \\
X_6 &= \text{price of slaughter beef per 100 pounds received by United States farmers in the preceding year and expressed in real terms.}
\end{align*}

From these price equations of national prices it was possible to estimate prices in Oregon by plugging the estimates of United States prices into a simple regression expressing the relationship between national and state prices. The resulting estimates of Oregon prices compared very favorably with actual prices in the state, the average percent difference between actual and estimated prices being 3.87 percent in the case of slaughter cattle prices, while feeder and stocker cattle showed only a 2.65 average percent difference. On the national scale the average percent difference between actual and estimates of prices was even lower, being 1.92 percent in the case of slaughter cattle and only 1.54 percent for stocker and feeder cattle.
A general conclusion can be drawn from the results of this study, in that an investigation of prices and trends in the United States can serve as a satisfactory guide as to what is happening within the state of Oregon.
AN ECONOMIC ANALYSIS OF BEEF CATTLE PRICES

by

DAVID WALLACE NORMAN

A THESIS

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Purpose of study and objectives</td>
<td>1</td>
</tr>
<tr>
<td>Methodology</td>
<td>2</td>
</tr>
<tr>
<td>Limitations of the study</td>
<td>4</td>
</tr>
<tr>
<td>Unfulfilled assumptions of the Gauss-Markoff theorem</td>
<td>4</td>
</tr>
<tr>
<td>Unavailability of data</td>
<td>6</td>
</tr>
<tr>
<td>II THE BEEF CATTLE INDUSTRY IN OREGON</td>
<td>7</td>
</tr>
<tr>
<td>Importance of Oregon's contribution to the United States</td>
<td>7</td>
</tr>
<tr>
<td>Numbers of beef cattle</td>
<td>8</td>
</tr>
<tr>
<td>Numbers of feeders and stockers</td>
<td>13</td>
</tr>
<tr>
<td>Numbers of cattle slaughtered</td>
<td>17</td>
</tr>
<tr>
<td>Analysis of monthly slaughter</td>
<td>21</td>
</tr>
<tr>
<td>Relative importance of beef cattle compared with dairy cattle in Oregon</td>
<td>29</td>
</tr>
<tr>
<td>III ANALYSIS OF BEEF CATTLE CYCLES</td>
<td>35</td>
</tr>
<tr>
<td>Theoretical aspects</td>
<td>35</td>
</tr>
<tr>
<td>Cobweb theorem</td>
<td>36</td>
</tr>
<tr>
<td>The internal mechanism of the beef cattle cycle</td>
<td>39</td>
</tr>
<tr>
<td>Empirical results</td>
<td>41</td>
</tr>
<tr>
<td>Procedure</td>
<td>41</td>
</tr>
<tr>
<td>Results and conclusions</td>
<td>42</td>
</tr>
<tr>
<td>IV SEASONAL VARIATION IN PRICES AND PRODUCTION OF SLAUGHTER AND FEEDER CATTLE</td>
<td>46</td>
</tr>
<tr>
<td>Slaughter cattle</td>
<td>47</td>
</tr>
<tr>
<td>Seasonal price variation for slaughter beef (all grades) in the United States and Oregon</td>
<td>47</td>
</tr>
<tr>
<td>Seasonal price and production variation for slaughter beef (all grades) in Oregon</td>
<td>50</td>
</tr>
<tr>
<td>Seasonal price variation of specified grades of slaughter beef in Oregon</td>
<td>57</td>
</tr>
<tr>
<td>Stocker and feeder cattle</td>
<td>61</td>
</tr>
<tr>
<td>V FACTORS INFLUENCING THE ANNUAL PRICE OF SLAUGHTER BEEF CATTLE AT THE SLAUGHTER HOUSE LEVEL</td>
<td>65</td>
</tr>
<tr>
<td>The theoretical development of the slaughter beef market</td>
<td>65</td>
</tr>
</tbody>
</table>
### Chapter 1: Demand for slaughter beef cattle at the slaughter house level
- Demand for a factor of production ........................................ 66
- Variables influencing factor demand ...................................... 67
- Rationale behind the variables in the demand equation ............. 73

### Chapter 2: The supply of slaughter beef cattle at the slaughter house level
- Variables affecting the supply of slaughter cattle .................... 79
- Rationale behind the inclusion of the variables in the supply equation ........................................ 79

### Chapter 3: Equilibrium point
- Derivation of the price equation ........................................ 84

### Chapter 4: Empirical results
- Oregon and United States annual prices ................................ 86
- Time period selected ................................................................ 86
- Modifications to the price equation ...................................... 86
- Results and implications of the stepwise regression ................... 88
- Value of the estimating equation ........................................ 92

### VI: Factors Influencing the Annual Price of Feeders and Stockers
- Theoretical development of the feeder and stocker cattle market .................................................. 101
- Demand for a factor of production ...................................... 101
- The supply of stocker and feeder cattle ................................. 104
- Equilibrium point ............................................................... 105
- Rationale behind the inclusion of the variables in the diagram ...................................................... 105
- The model ........................................................................ 110

### Empirical results
- Oregon and United States prices ........................................ 111
- Time period selected .......................................................... 113
- Modifications to the price equation ...................................... 113

### Results of the regression analysis
- Interpretation of regression equation (2) .............................. 118
- Assessment of the value of the regression equation ................. 120

### Estimation of annual price of feeders and stockers in Oregon
- ................................................................................. 121
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>VII SUMMARY AND CONCLUSIONS</td>
<td>128</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>132</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>135</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adjusted numbers of beef animal unit months in Oregon and the United States, 1944-1961</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Adjusted numbers on feed January 1 in Oregon and the United States, 1944-1961</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Oregon and United States adjusted commercial cattle slaughter by years in pounds liveweight, 1944-1961</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>Adjusted numbers of head of beef cattle commercially slaughtered by months, 1944-1961</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>Adjusted percentage contribution of beef cattle commercially slaughtered by months, 1944-1961, (a) in numbers of head</td>
<td>26</td>
</tr>
<tr>
<td>7</td>
<td>Adjusted percentage contribution of beef cattle commercially slaughtered by months, 1944-1961, (b) in pounds liveweight</td>
<td>27</td>
</tr>
<tr>
<td>8</td>
<td>Adjusted percentage contribution of beef cattle commercially slaughtered in Oregon by months, 1944-1961</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>Adjusted numbers of beef and dairy cattle in Oregon, 1944-1961</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>Three possible phases of the Cobweb Theorem</td>
<td>38</td>
</tr>
<tr>
<td>11</td>
<td>Internal mechanism of the beef cattle cycle</td>
<td>40</td>
</tr>
<tr>
<td>12</td>
<td>Cyclical relatives for average prices of beef received by United States farmers, and numbers of other cattle on farms, January 1, 1910-1962</td>
<td>43</td>
</tr>
<tr>
<td>13</td>
<td>Seasonal price variation of beef cattle commercially slaughtered (all grades) in Oregon and the United States</td>
<td>48</td>
</tr>
<tr>
<td>Figure</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Seasonal price variation of beef cattle commercially slaughtered (all grades) in Oregon compared with seasonal variation in numbers of head commercially slaughtered (all grades) in Oregon for 1951-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Seasonal price variation of choice steers and good heifers at Portland (Oregon), 1951-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Seasonal variation in prices and numbers of head of feeder and stocker steers marketed at Kansas City, 1951-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Marketing levels of slaughter beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Diagram showing factors important in determining the annual price of slaughter beef (all grades) received by United States farmers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Actual and estimated real prices per 100 pounds of commercially slaughtered beef received by United States farmers, 1947-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Actual and estimated real prices per 100 pounds of commercially slaughtered beef received by Oregon farmers, 1947-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>Diagram showing the factors considered important in determining the annual price of feeders and stockers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Correlation of annual prices between various feeder and stocker markets, 1947-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>Actual and estimated real prices per head of feeder and stocker cattle in the United States, 1947-1962</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>Actual and estimated prices per 100 pounds in real terms of feeder and stocker good and choice steers at Ontario (Oregon), 1947-1962</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A. U. M. 's in Oregon and the United States, 1944-1961</td>
<td>9</td>
</tr>
<tr>
<td>2 Percent rates of growth in beef cattle numbers in Oregon and the United States expressed in A. U. M. 's, 1944-1961</td>
<td>12</td>
</tr>
<tr>
<td>3 Numbers of head on feed January the first in Oregon and the United States, 1944-1961</td>
<td>13</td>
</tr>
<tr>
<td>4 Percent rates of growth in numbers of head on feed in Oregon and the United States, 1944-1961</td>
<td>16</td>
</tr>
<tr>
<td>5 Numbers of cattle commercially slaughtered in Oregon and the United States, 1944-1961</td>
<td>17</td>
</tr>
<tr>
<td>6 Pounds liveweight commercially slaughtered in Oregon and the United States, 1947-1961</td>
<td>18</td>
</tr>
<tr>
<td>7 Percent rates of growth in numbers slaughtered in Oregon and the United States, 1944-1961</td>
<td>21</td>
</tr>
<tr>
<td>8 Percent contribution by month to total slaughter in Oregon and the United States</td>
<td>25</td>
</tr>
<tr>
<td>9 Comparison of numbers and percent rates of change in A. U. M. 's of beef and dairy cattle in Oregon, 1944-1961</td>
<td>29</td>
</tr>
<tr>
<td>10 Dairy cattle compared with feeder and slaughter cattle in terms of numbers of head and percent rates of growth Oregon 1944-1961</td>
<td>33</td>
</tr>
<tr>
<td>11 Dates in turning points in the beef cattle cycle in the United States, 1910-1962</td>
<td>44</td>
</tr>
<tr>
<td>12 Exogenous and endogenous variables of a model used for investigating the factors important in determining the farm price of beef</td>
<td>84</td>
</tr>
<tr>
<td>13 Comparison of actual and estimated real prices per 100 pounds of commercially slaughtered beef received by United States farmers, 1947 to 1962</td>
<td>93</td>
</tr>
<tr>
<td>14 Comparison of actual and estimated real prices per 100 pounds of commercially slaughtered beef received by Oregon farmers, 1947 to 1962</td>
<td>97</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>15 Comparison of actual and estimated real prices per head of feeder and breeding cattle in the United States, 1947 to 1962</td>
<td>122</td>
</tr>
<tr>
<td>16 Comparison of actual and estimated real prices per 100 pounds of feeder and stocker, choice and good steers (under 700 pounds) at Ontario (Oregon), 1947 to 1962</td>
<td>125</td>
</tr>
<tr>
<td>17 Seasonal relatives for cattle in Oregon and the United States</td>
<td>135</td>
</tr>
</tbody>
</table>
ECONOMIC ANALYSIS OF BEEF CATTLE PRICES

CHAPTER 1

INTRODUCTION

Purpose of study and objective

In spite of the existence of demand for beef in Oregon, farmers traditionally have failed to supply all the beef demanded by the residents and consequently shipments from areas outside the state have achieved some importance. The result today is that the beef industry in Oregon is a relatively small contributor to the national aggregate although in the state itself it appears to achieve a position of some importance.

As a result, the general purpose of this study was to compare prices and production of beef cattle in Oregon with the United States as a whole. More specifically, three main objectives were defined:

1. To assess the importance of Oregon's production of beef as far as the United States as a whole is concerned, and to investigate whether or not the state is becoming a more significant contributor to the nation. Coupled with this was an attempt to study the importance of beef production in Oregon, relative to the dairy industry inside the state, and to determine if the relationship of one to the other is changing over time.

2. The second major objective was to compare annual and seasonal trends of prices and production in Oregon, with the United
States, together with explanations for any differences that were to be found.

3. The final objective was to investigate the factors important in determining prices of slaughter and feeder and stocker cattle in Oregon and the United States.

**Methodology**

In order to fulfill the above objectives considerable emphasis was placed on statistical techniques, particularly regression analysis or the method of least squares.

Simple linear regression (20, p. 244-303) was utilized for the preliminary analysis while stepwise regression was employed in deriving price equations for slaughter and stocker and feeder cattle.

Briefly, stepwise regression, which is conveniently carried out on a computer, commences with the calculation of simple correlation coefficients between the dependent variable $Y$, and each of the independent variables, $X_1 \ldots X_n$. The correlation coefficients are then ranked in order of magnitude. The first regression run is between $Y$ and the $X$ variable having the highest correlation with $Y$. Then, a new regression is run with two independent variables, which are the highest and second highest on the list. The

---

1 Other methodological considerations of less importance pertaining to specific parts of the study are embodied in the text itself.
process is continued until all the variables are included in the equation.

From a statistical standpoint two factors are important in determining which least squares estimate should be adopted as an estimate of the dependent variable Y. The factors to consider are the correlation coefficient and the standard error of estimate. As more variables are added the multiple correlation coefficient increases monotonically, while at the same time the standard errors of estimate decrease and then increase. The least squares equation to accept is the one where the multiple correlation coefficient is significant and the standard error of estimate is near its minimum value.

For analyzing seasonal variation in prices and production, the ratio to moving average method was utilized (27, p. 294). The first step in this method is to eliminate seasonal and irregular fluctuations from the data by using a twelve month moving average which approximates trend and cyclical fluctuations. Thus the original data which contain trend, cyclical, seasonal and irregular characteristics are then corrected for trend and cyclical fluctuations by dividing by the moving average values as is shown below:

\[
\frac{T. S. C. I.}{T. C.} = S. I.
\]

The results are seasonal relatives which are expressed in percentage terms. The irregular elements are then eliminated by taking the
median values of the resulting seasonal relatives of each month, thereby obtaining the typical seasonal relative for each month. Finally the typical seasonal relatives are adjusted so that the sum of the 12 months equals 1200. To determine if any significant seasonal variation in the price or production series occurs, a two way analysis of variance (20, p. 196-214) is carried out, using the months as treatments and the years as replications.

**Limitations of the study**

Two main limitations apply to this study, one of a theoretical and one of a practical nature.

**Unfulfilled assumptions of the Gauss-Markoff theorem**

In any statistical analysis involving regression, there are certain assumptions that have to be realized if the results are to achieve any degree of validity.

The use of regression analysis arises as a result of the Gauss-Markoff theorem which can be stated as follows.

Consider a number n of uncorrelated observations y, which are distributed with common variance $\sigma^2$ about a mean $\sum_{j=1}^{p} \beta_j X_{ij}$ where the $\beta_j$'s are unknown parameters while the $X_{ij}$'s are known constants. The best linear unbiased estimates of $\beta_1, \beta_2, \ldots, \beta_p$ are solutions of a system of linear equations obtained by minimizing the residual sum of squares $\sum_{i=1}^{n} (y_i - \beta_1 X_{i1} - \beta_2 X_{i2} - \ldots - \beta_p X_{ip})^2$.
with respect to the unknown parameters. Therefore for this theorem and regression analysis to be valid, certain conditions or specifications have to be fulfilled. Those relating to the residual or error terms (u) are (11, p. 58 and 34, p. 77):

1. That \( u_i \) for all i's are random variables \( i = 1, \ldots, n \) where i is the equation number.

2. The average or expected value of \( u_i \)'s equals zero.
   i.e. \( E(u_i) = 0 \) for all i's.

3. That \( u_i \) has constant variance.
   i.e. \( E(u_i^2) = \sigma_i^2 \)

4. \( u_i \)'s are not correlated and therefore are not auto-correlated.
   i.e. \( E[u_i(t), u_i(t-1)] = 0 \)

5. \( u_i \) is not correlated with any exogenous variable.
   i.e. \( \text{Cov}(u_iX_{ij}) = 0 \)

When working with economic data, these conditions or specifications are usually assumed to be held. However assumption four, that the u's are serially independent or not autocorrelated is particularly important and if not found to be upheld, can detract considerably from the value of a regression equation. It becomes of considerable significance when dealing with time series data. In the case of the preliminary simple regressions in this study, it was

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1 A more detailed discussion is given by Graybill (15, p. 114).
felt that there was little object in testing for autocorrelation. However, in the case of the multiple regression results in Chapters 5 and 6 there was considered to be some value in employing the Durbin and Watson test (8, p. 159) for testing for serial independence.

In using the Durbin and Watson test the following statistic is computed:

\[
d' = \frac{\sum_{t=2}^{N} (d_t - d_{t-1})^2}{\sum_{t=1}^{N} d_t^2}
\]

where \(d_t\) is the unexplained residual for observation \(t\) and \(N\) is the number of observations. A table (8, p. 169 or 12, p. 76) is used to obtain the critical regions (\(d_L\) and \(d_u\)). If \(d'\) or \(4-d'\) is less than \(d_L\), then it is assumed that positive (i.e. if \(d'\) is less than \(d_L\)) or negative (i.e. if \(4-d'\) is less than \(d_L\)) serial correlation exists. If both of the values are greater than \(d_u\), it is assumed that there is no serial correlation. If neither of the computed values is less than \(d_L\), but one of them lies between \(d_L\) and \(d_u\), the test is inconclusive.

The verification of the fact that no autocorrelation is present enhances the validity of a regression equation.

Unavailability of data

Limitations imposed by lack of relevant data were sometimes a very real problem, especially in the case of data within the state of Oregon.
CHAPTER 2

THE BEEF CATTLE INDUSTRY IN OREGON

The following analysis shows that Oregon's beef cattle industry is comparatively unimportant relative to the national industry. However in Oregon itself, beef cattle account for a high percentage of the total cattle present in the state, and as a result could be considered to achieve considerable importance in the economy of Oregon.

The period 1944 to 1961 inclusive was selected for the purpose of this analysis, except where otherwise stated.

Importance of Oregon's contribution to the United States

Approximately one percent of the United States' population reside in Oregon and receive per capita income somewhat above the national average. As meat consumption tends to increase with an increase in disposal income per capita, \(^1\) it is reasonable to conclude that Oregon consumes more than one percent of the national beef supply. This phase of the study is confined, however, to production aspects. The purpose of this section is to measure Oregon's contribution as a producer to beef production in the United States as a whole.

\(^1\) See footnote on page 77 of this study.
With this aim in mind, this section was divided into three parts: namely numbers of beef cattle, numbers of feeders and numbers slaughtered.

**Numbers of beef cattle**

As beef cattle as a whole include cows, calves, steers, and bulls, it was deemed necessary to convert these to a common denominator. The common denominator used was to convert them on a basis of the relative amounts of feed, bulls, steers, cows, and calves consumed per month. Thus numbers of beef cattle were expressed in terms of animal unit months. The conversion ratios used for different classes of beef cattle were:

- Cows and heifers, two years old and over: 1.0 A.U.M.
- Heifers, one to two years old: 0.8 A.U.M.
- Calves: 0.6 A.U.M.
- Steers, one year old and over: 0.8 A.U.M.
- Bulls, one year old and over: 1.25 A.U.M.'s

The results shown in Table 1 were obtained on comparing numbers of unit months in Oregon with those in the United States for the years 1944 to 1961 inclusive.

It is interesting to note that numbers of animal unit months in Oregon and the United States tended to move together. For

---

1 The data used for this section (31, p. 314) were numbers of other cattle, which are defined as total numbers of cattle minus those kept specifically for milk.
On investigating whether numbers of beef cattle in Oregon were growing significantly during the period 1944 to 1961, the following results were obtained:

\[ \hat{Y} = 516.480 + 26.493X \]

\[ (8.6750) \]  

\[ r = 0.9081 \]  

\[ r^2 = 0.8246 \]

Example: The lowest numbers in Oregon and the nation both occurred in 1948, while the highest numbers were found in adjacent years, i.e., 1960 and 1961. In fact, there proved to be a correlation of 0.9871 between the two series of animal unit months.

Table 1. A.U.M.'s in Oregon and the United States, 1944-1961.

<table>
<thead>
<tr>
<th>Year</th>
<th>A.U.M.'s (thousands)</th>
<th>Year</th>
<th>A.U.M.'s (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1948</td>
<td>34,385</td>
<td>1948</td>
</tr>
<tr>
<td>Maximum</td>
<td>1960</td>
<td>54,372</td>
<td>1961</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>43,932</td>
<td></td>
</tr>
</tbody>
</table>

On investigating whether numbers of beef cattle in Oregon were growing significantly during the period 1944 to 1961, the following results were obtained:

1 See also Figure 1.
2 Significant at the one percent level.
3 The t-value is significant at the one percent level.
4 The correlation coefficient is significant at the one percent level.
Figure 1. Adjusted numbers of beef animal unit months in Oregon and the United States, 1944-1961.
\[ S_b = 3.0542 \]

where:

\[ X = \text{years} \]

\[ \hat{Y} = \text{animal unit months in Oregon}. \ (1,000 \text{ A.U.M.'s}) \]

Therefore numbers of animal unit months (i.e. numbers of beef cattle) in Oregon were found to be increasing significantly in absolute terms.

However it is more important for the purposes of this study to determine whether or not Oregon's contribution to national population is increasing significantly. The percentage contribution of Oregon to national population during the period investigated varied from a minimum of 1.610 in 1951 to a maximum of 1.840 in 1955, with a mean contribution of 1.732 percent. The results of a simple regression between years and percentage contribution were:

\[ \hat{Y} = 1.656 + 0.00798 \times X \]

\( r = 0.5596 \)

\( r^2 = 0.3131 \)

\[ S_b = 0.003179 \]

where:

\[ X = \text{years} \]

---

1 Using 1944 as year 1.
2 \( t \) value is significant at the 2.5 percent level.
3 Significant at the five percent level.
\[ \hat{Y} = \text{percent contribution of Oregon to the United States in terms of animal unit months.} \]

Therefore during the period 1944 to 1961 the percent contribution of Oregon to the United States population, in terms of animal unit months, did in fact increase significantly, although it should be noted that Oregon began as a very insignificant contributor. In terms of percentage rates of growth Oregon has also shown favorable increases when compared with the United States.


<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>Oregon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Percent rate of growth</td>
<td>Year</td>
</tr>
<tr>
<td>Maximum</td>
<td>1951-1952</td>
<td>13.16</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>2.50</td>
</tr>
</tbody>
</table>

Understandably numbers of animal units in Oregon fluctuated more than those in the United States although the minimum and maximum years occurred at the same time.

Numbers of beef cattle include feeders and stockers, and cattle ready for slaughter, both of which will now be considered in turn.
Numbers of feeders and stockers

Slaughter cattle derive from two main sources, namely those sold off the range as grass fattened animals and those that pass through feedlots where they undergo a period of intensive feeding with a high proportion of concentrate feed. A very high percentage of slaughter cattle actually pass through feedlots and consequently feeders and stockers play an important role in the beef cattle industry.

A comparison of numbers of cattle on feed January the first yielded the results shown in Table 3.

Table 3. Numbers of head on feed January the first in Oregon and the United States, 1944-1961.

<table>
<thead>
<tr>
<th>Year</th>
<th>United States Numbers on feed (thousand head)</th>
<th>Oregon Numbers on feed (thousand head)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>3,821</td>
<td>1948</td>
</tr>
<tr>
<td>Maximum</td>
<td>7,645</td>
<td>1961</td>
</tr>
<tr>
<td>Mean</td>
<td>5,305</td>
<td>41</td>
</tr>
</tbody>
</table>

Once again numbers of animals on feed moved together and in fact a correlation coefficient of 0.9047 was found to exist between...
Figure 2. Adjusted numbers on feed January 1, in Oregon and the United States, 1944-1961.
Concerning growth aspects, numbers of head on feed in Oregon were found to be increasing significantly during the period.

\[ \hat{Y} = 15.454 + 2.648X \]

\( r = 0.7682 \)

\( r^2 = 0.8765 \)

\( S_b = 0.3638 \)

where:

\( X \) = years

\( \hat{Y} \) = numbers of head on feed in Oregon (1,000 head)

Therefore numbers of head on feed in Oregon were found to be increasing significantly as indeed was Oregon's percentage contribution to the United States total.

\[ \hat{Y} = 0.574 + 0.017X \]

\( r = 0.6581 \)

\( r^2 = 0.4331 \)

\( S_b = 0.0052 \)

where:

1 Significant at the one percent level.

2 Significant at the one percent level.
\( X \) = years

\( Y \) = percentage contribution of Oregon to the United States in terms of numbers of head of feeders.

Oregon's percentage contribution to the national total has actually been very small, varying from a low of 0.521 in 1953 to a high of 0.985 in 1959, with a mean of 0.736 percent.

On investigating the average percentage rate of growth in numbers of head on feed, it was found that Oregon was expanding at a faster rate per annum than the United States, although there was more fluctuation in annual rates of growth in Oregon.

Table 4. Percentage rates of growth in numbers of head on feed in Oregon and the United States, 1944-1961.

<table>
<thead>
<tr>
<th>United States</th>
<th>Year</th>
<th>Percent rate of growth</th>
<th>Year</th>
<th>Percent rate of growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>1952-1953</td>
<td>16.15</td>
<td>1954-1955</td>
<td>43.75</td>
</tr>
<tr>
<td>Average</td>
<td>4.17</td>
<td></td>
<td>5.80</td>
<td></td>
</tr>
</tbody>
</table>
Numbers of cattle slaughtered

Both in the United States and in Oregon numbers of cattle slaughtered are increasing over the years due to increased demand for beef resulting from population growth and higher disposable incomes per capita. The statistics shown in Table 5 compare numbers of cattle slaughtered in Oregon with those slaughtered in the United States.


<table>
<thead>
<tr>
<th>Year</th>
<th>United States</th>
<th>Oregon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Numbers of head (thousand head)</td>
<td>Year</td>
</tr>
<tr>
<td>Minimum</td>
<td>1951</td>
<td>16,376.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>1956</td>
<td>26,861.7</td>
</tr>
<tr>
<td>Mean</td>
<td>21,860.8</td>
<td>234.3</td>
</tr>
</tbody>
</table>

Once again a high correlation coefficient of 0.9353 was found to exist between numbers of head commercially slaughtered in the United States and in Oregon.

In addition to comparing Oregon and the United States in terms of numbers of head slaughtered, a similar comparison was

---

1 Data used were those cattle slaughtered commercially, as these constitute a very high percentage of total numbers slaughtered.

2 Significant at the one percent level.
carried out on the basis of liveweight commercially slaughtered. Figure 3 shows that Oregon commercial slaughter in terms of pounds liveweight appeared to fluctuate more in Oregon than for the United States as a whole and that the timing of the troughs and peaks were approximately the same. In terms of absolute numbers of pounds liveweight commercially slaughtered the results shown in Table 6 were obtained.


<table>
<thead>
<tr>
<th>Year</th>
<th>Total liveweight (thousand pounds)</th>
<th>Year</th>
<th>Total liveweight (thousand pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1951</td>
<td>15,758,554</td>
<td>1951</td>
</tr>
<tr>
<td>Maximum</td>
<td>1956</td>
<td>25,682,630</td>
<td>1956</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>21,399,337</td>
<td></td>
</tr>
</tbody>
</table>

It is interesting to note that the minimum and maximum years were the same in both numbers of head and pounds liveweight commercially slaughtered.

Numbers of cattle commercially slaughtered in Oregon were found to be increasing significantly during the period 1944 to 1961 as the following results show:

1 Data for years prior to 1947 were unavailable.
2 Data for years prior to 1947 were unavailable.
Figure 3. Oregon and United States adjusted commercial cattle slaughter by years in pounds liveweight, 1944-1961.
\[ \hat{Y} = 192.406 + 4.411X \]
\[ (3.3518) \]
\[ r = 0.6725 \]
\[ r^2 = 0.4523 \]
\[ S_b = 1.316 \]

where:

- \( X \) = years
- \( \hat{Y} \) = numbers of head slaughtered in Oregon (1000 head)

However on a percent contribution basis there appeared to be no significant increase in Oregon's share of national slaughter.

\[ \hat{Y} = 1.090 - 0.00180 \]
\[ (-0.5377) \]
\[ r = 0.1715 \]
\[ r^2 = 0.0294 \]
\[ S_b = 0.003351 \]

where:

- \( X \) = years
- \( \hat{Y} \) = percent contribution of Oregon to national slaughter.

Therefore although numbers slaughtered in Oregon were increasing significantly, they were not increasing as rapidly as

---

1 Significant at the one percent level.
2 Significant at the one percent level.
slaughter in the nation with the result that Oregon's share of the national market was essentially unchanged. Throughout the period studied Oregon's percent contribution to United States total varied from a low of 0.975 in 1944 to a high of 1.231 in 1949 with a mean contribution of 1.072 percent.

Average percent rates of growth on numbers slaughtered per annum in the United States and Oregon are compared in the following table.


<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>Oregon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year</td>
<td>Percent rate of growth</td>
</tr>
<tr>
<td>Maximum</td>
<td>1952-1953</td>
<td>32.20</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.32</td>
</tr>
</tbody>
</table>

Monthly slaughter fluctuates considerably during any one year and consequently was considered to be worthy of investigation.

Analysis of monthly slaughter

In terms of numbers of head commercially slaughtered it was found that the peak slaughter months in Oregon during the period 1944 to 1961 were August and September compared with
October for the United States as a whole. In addition to this, Figure 4 shows that Oregon slaughter tends to fluctuate more than in the United States as a whole. The rationale behind the fluctuations in monthly slaughter are discussed in Chapter 4.

The purpose at this point is simply to indicate how the pattern of monthly slaughtering has changed in Oregon during the period studied. To accomplish this objective, the period 1944 to 1961 was broken down into three sub-periods delineated by trough points in the beef cattle price cycle. Adjusted beef cattle slaughter indexes were calculated for these three sub-periods and gave rise to the results shown in Figure 5. The results showed that the peak slaughter month in Oregon appears to have exhibited a definite trend towards an earlier date than in the United States as a whole. During the period 1944 to 1949 the peak slaughter month was October, this being replaced by August and September during the middle period, while by the latest period 1956 to 1961, the peak slaughter month had become August. At the same time there appeared to be a trend towards less fluctuation in amplitude of numbers slaughtered. This is illustrated by comparing the periods 1944 to 1949 and 1950 to 1955 with period 1956 to 1961. The move towards less fluctuation in slaughter could be due to the trend towards large feedlot operators who place a steadier monthly stream

1 See page 43 of this study.
Figure 4. Adjusted numbers of head of beef cattle commercially slaughtered by months, 1944-1961.
Figure 5. Adjusted numbers of beef cattle commercially slaughtered by months in Oregon, 1944-1949, 1950-1955, 1956-1961.
of fattened cattle on the market than would be the case with many small individual operators.

In terms of the percentage contribution by month, the values of three statistics were considered to be worthy of note. These statistics were calculated on the basis of numbers of head slaughtered and pounds liveweight slaughtered, and gave rise to the results shown in Table 8.

Table 8. Percent contribution by month to total slaughter in Oregon and the United States.

<table>
<thead>
<tr>
<th></th>
<th>Percent Oregon contributes to U.S. total by month</th>
<th>Percent Oregon contributes to Oregon total by month</th>
<th>Percent U.S. contributes to U.S. total by month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Numbers of head Slaughtered</td>
<td>Liveweight Slaughtered</td>
<td>Numbers of head Slaughtered</td>
</tr>
<tr>
<td></td>
<td>% month</td>
<td>% month</td>
<td>% month</td>
</tr>
<tr>
<td>Mean</td>
<td>1.07 --  1.07 --</td>
<td>2.03 --  1.90 --</td>
<td>2.03 --  1.76 --</td>
</tr>
</tbody>
</table>

Table 8 and Figures 6, 7 help to reinforce the fact previously observed, that the peak slaughter month in Oregon was in August compared with the United States as a whole, where it occurred in

---
1 Years used for numbers of head slaughtered were 1944 to 1961, while 1947 to 1961 were used for liveweight slaughtered. Data for years 1944 to 1946 were not available for the latter.
Figure 6. Adjusted percentage contribution of beef cattle commercially slaughtered by months, (a) in numbers of head, 1944-1961.

- Adjusted percent contribution by month of the U.S. to U.S. total.
- Adjusted percent contribution by month of Oregon to the Oregon total.
- Adjusted percent contribution by month of Oregon to the U.S. total.
Figure 7. Adjusted percentage contribution of beef cattle commercially slaughtered by months, (b) in pounds liveweight, 1944-1961.

- Adjusted percent contribution by month of U.S. to U.S. total.
- Adjusted percent contribution by month of Oregon to the Oregon total.
- Adjusted percent contribution by month of Oregon to the U.S. total.
Figure 8. Adjusted percentage contribution of beef cattle commercially slaughtered by months, 1944-1961.

- Adjusted percentage contribution by month of Oregon to Oregon total in pounds liveweight.
- - - Adjusted percentage contribution by month of Oregon to Oregon total in number of head.
October. The Table and Figure 8 also serve to illustrate that numbers of head and total liveweight commercially slaughtered moved very closely together. It is interesting to note the fact that the percentage contribution of Oregon to the United States total reached its maximum in March and June to be followed with a minimum in December. These do not correspond with maximum and minimum slaughter months in Oregon but do serve to indicate that in March and June Oregon was slaughtering a relatively higher proportion of the total nation's beef while in December the opposite was found. This is well illustrated in Figures 6 and 7.

Relative importance of beef cattle compared with dairy cattle in Oregon

Beef and dairy cattle numbers were once more converted to animal unit months, using the same conversion ratios specified in the previous section. The results shown in Table 9 were obtained.


<table>
<thead>
<tr>
<th></th>
<th>Dairy</th>
<th></th>
<th>Beef</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year</td>
<td>Numbers of A.U.M.'s (thousands)</td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>1944</td>
<td>482</td>
<td>1949-‘50</td>
</tr>
<tr>
<td>Minimum</td>
<td>1961</td>
<td>308</td>
<td>1945-'46</td>
</tr>
<tr>
<td>Mean</td>
<td>384</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9 indicates that numbers of beef cattle are increasing at the expense of the dairy industry which appears to be declining. In fact it was found that numbers of beef cattle were increasing significantly compared with dairy animals.

\[ \hat{Y} = 56.39 + 34.52 X \]

\( (14.0439)^1 \)

\[ r = 0.9640^2 \]

\[ r^2 = 0.9293 \]

\[ S_b = 2.4580 \]

where:

\[ X = \text{years} \]

\[ \hat{Y} = \text{numbers of beef cattle (in A.U.M.'s) in Oregon minus numbers of dairy cattle (in A.U.M.'s) in Oregon.} \]

In comparing dairy numbers with feeder and slaughter cattle it was found that once again dairy cattle compared unfavorably (See Table 10, p. 33).

The following simple regressions also serve to illustrate the fact that feeder and slaughter numbers were increasing significantly compared with dairy numbers.

\[ \hat{Y} = 3160 - 9.550 X \]

---

1 Significant at the one percent level.
2 Significant at the one percent level.
\((-12.6373)^1\)

\(r = 0.3323\)

\(r^2 = 0.1104\)

\(S_b = 0.7557\)

where:

\(X = \) years

\(\hat{Y} = \) dairy numbers minus feeder numbers in Oregon

\(\hat{Y} = 232.118 - 11.556 \times \)

\((-8.0414)^1\)

\(r = 0.4771\)

\(r^2 = 0.2277\)

\(S_b = 1.437\)

where:

\(X = \) years

\(\hat{Y} = \) dairy numbers minus slaughter numbers in Oregon

The trends indicated above are illustrated in Figure 9 which shows numbers adjusted to a base level of 100.

It appears dairy numbers were losing ground relative to beef cattle. However, it also appears from Figure 9 that numbers of cattle on feed in Oregon were increasing at a greater rate than

\(^1\) Significant at the one percent level.
Figure 9. Adjusted numbers of beef and dairy cattle in Oregon, 1944-1961.

Index

- Numbers of beef cattle in A.U.M.'s
- Numbers of head on feed January 1.
- Numbers of head slaughtered.
- Numbers of dairy cattle in A.U.M.'s

Years


0 20 40 60 80 100 120 140 160
slaughter numbers, although it was found that the rates of growth were not significantly different.

Table 10. Dairy cattle compared with feeder and slaughter cattle in terms of numbers of head and percent rates of growth, Oregon, 1944-1961.

<table>
<thead>
<tr>
<th>Year</th>
<th>Numbers of head (thousand)</th>
<th>Percent rates of growth</th>
<th>Year</th>
<th>Numbers of head (thousand)</th>
<th>Percent rates of growth</th>
<th>Year</th>
<th>Numbers of head (thousand)</th>
<th>Percent rates of growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1961 289</td>
<td>1946 -10.37</td>
<td>1948 24</td>
<td>1947- -25.0</td>
<td>1951 164.6</td>
<td>1947--20.64</td>
<td>1948 146</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>356.7</td>
<td>-2.20</td>
<td>40.6</td>
<td>5.80</td>
<td>234.3</td>
<td>3.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \hat{Y} = 3.831 + 0.579 \]

\( (0.7153) \)

\[ r = 0.1789 \]

\[ r^2 = 0.0322 \]

\[ S_b = 0.8089 \]

where:

\[ X = \text{years} \]

\[ \hat{Y} = \text{rate of change in slaughter numbers in Oregon minus rate of change in numbers on feed in Oregon} \]
In conclusion, it appears that during the period studied, Oregon's beef cattle industry was an insignificant contributor as far as the United States was concerned, but inside the state of Oregon itself numbers of beef cattle were becoming increasingly important relative to numbers in the dairy industry. Finally it also appears that numbers of cattle on feed in Oregon were growing at a relatively faster rate of 5.80 percent per annum than numbers of slaughter cattle which were growing at a rate of 3.07 percent per annum.

The results in the preceding analysis indicate in general that Oregon's beef cattle industry has followed the same patterns in production, feeding and slaughter as the United States. This may surprise those that may have felt Oregon's beef cattle industry has shown less development and progress than the United States as a whole. Those that have felt that Oregon's beef cattle industry progressed and has followed a consistent development may use these results to substantiate their views.
CHAPTER 3

ANALYSIS OF BEEF CATTLE CYCLES

Theoretical aspects

Gordon (14, p. 219) states that there are two sets of forces at work to cause constant change, one leading to gradual movements over long periods and the other creating short-period fluctuations. There is now general agreement among economists and statisticians that the dynamic forces operating on the economy create at least four types of movements or fluctuations. They are:

1. Long-run or secular movements,
2. Cyclical fluctuations,
3. Seasonal variations,
4. Random or sporadic changes that do not fit into the other three categories.

Cycles can be considered as consisting of recurring alternations of expansion and contraction in activity, the alternating movements in each direction being self-reinforcing and pervading virtually all parts of the economy.\(^1\)

A theoretical reason explaining why lags in production responses to price changes can give rise to cyclical fluctuations is

---

\(^1\) This is a definition modeled on the one given by Gordon (14, p. 249) for business cycles.
offered by the Cobweb Theorem.

Cobweb Theorem

The assumptions underlying the Cobweb Theorem are that both the demand and supply curves are fixed, and that supply is completely determined by the price in the preceding period. The Cobweb Theory can apply only to commodities which fulfill three conditions (9, p. 262):

1. Production must be completely determined by the producers' response to price, under conditions of pure competition (where the producer bases plans for future production on the assumption present prices will continue, and that his own production plans will not affect the market).
2. Where the time needed for production requires at least one full period before production can be changed, once the plans are made.
3. Where the price is set by the supply available. Obviously commodities where either price or production is set by administrative decisions (e.g. where monopolistic competition prevails), or where production can respond almost immediately to changed demands, cannot be expected to show the cobweb reaction.

Shepherd (25, p. 35) and Ezekiel (9, p. 262-271) differentiate three different phases of the Cobweb Theorem known as continuous fluctuations, convergent fluctuations and divergent fluctuations.

1. Continuous fluctuations. In this case, the elasticities of demand and supply are identical. As long as price is completely determined by the current supply, and supply is completely determined by the preceding price, fluctuation in price and production will continue in this unchanging pattern indefinitely, without an equilibrium being approached or reached. This relationship is
shown in Figure 10a.

2. Divergent fluctuations. Where the elasticity of supply is greater than the elasticity of demand, the series of reactions works out as shown in Figure 10b. Under such conditions the situation might grow more and more unstable, until price fell to absolute zero, or production was completely abandoned, or the elasticity of supply changes, resulting in a change in the relative elasticity of supply and demand.

3. Convergent fluctuations. In this case, elasticity of supply is less than the elasticity of demand. This is illustrated in Figure 10c. In this type of situation, assuming no changes in the elasticity of supply and demand, fluctuations decrease until the equilibrium is reached.

Ezekiel (9, p. 272-273) discussed the following limitations of the Cobweb Theorem:

1. Farmers can do little to increase their future production, once they have made their initial commitment in animals bred. However in practice there is some elasticity of response left, on the downward side.
2. Few commodities show clearly marked one-period, two-period, or three-period supply reactions.
3. Natural conditions such as weather have an effect on production.
4. Actual production may not swing from very high to very low, even with a one-year response.
5. There is no commodity for which the third condition (i.e. that the supply alone sets the price) is completely fulfilled.

In the cases considered to date, it has been assumed that a change of price in one period was reflected in a corresponding
Figure 10. Three possible phases of the Cobweb Theorem.  

Figure 10a  
Continuous Fluctuation

Figure 10b  
Divergent Fluctuation

Figure 10c  
Convergent Fluctuation

1 Source. (9, p. 262, 264)
change in production the following period. In many cases, such as beef cattle, two or more seasons may be required for the production period, so that two or more periods may elapse before the effect of price on production becomes apparent. The cycles in such cases will be several years in length. However the same general "cobweb" analysis applies although the exposition is somewhat more complicated.

The internal mechanism of the beef cattle cycle

Kohls (18, p. 120) considers that livestock production and prices especially, have more or less regular cycles in production and prices. That is, they tend to move up and down over a period of years regardless of outside factors.

Both Shepherd (25, p. 42) and Kohls (18, p. 120) state that the length of the cycle is dictated to a large extent by the biological nature of the commodity. In the case of beef cattle the gestation period for a cow is nine months, and a calf requires nearly two years to reach slaughter age.

A model depicting the internal mechanism of the beef cycle has been investigated by Maki (21, p. 739) who considered that the operation of the cycle can be presented by a chain of market and production variables. The chain of events in Figure 11 begins with feeder calf prices which are linked with beef cow inventories on January the first and, thence, to cattle slaughter and slaughter prices. Changes in beef cow inventories play an extremely critical
Figure 11. Internal mechanism of the beef cattle cycle.

<table>
<thead>
<tr>
<th>Market or production variable</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T-2$</td>
<td>$T-1$</td>
<td>$T$</td>
<td>$T+1$</td>
<td>$T+2$</td>
</tr>
<tr>
<td>Feeder calf price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other cattle on farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 1 (i.e. beef cattle)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 -- Calves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 -- Heifers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 -- Steers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 -- Cows</td>
<td></td>
<td></td>
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<tr>
<td>Commercial cattle slaughter</td>
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<tr>
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<tr>
<td>Feeder calf price</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

1 Source (21, p. 379)
role in accounting for both the period and the amplitude of the beef cycle. Maki continues by observing that, because of the cumulative processes involved in the initial phase of the cycle, an over estimation of equilibrium requirements may be corrected quickly by an increase in the placement of cows and heifers for slaughter. A small decrease in beef cow inventories, for example, would signal a much larger increase in commercial slaughter during the forthcoming year. Moreover, beef cows on farms would decline in numbers because of an increase in cow and heifer slaughter during the preceding year.

Empirical results

Procedure

As has been inferred in the preceding section, it is possible to study cyclical fluctuations from the standpoint of production and prices. In the present study it was felt desirable to do both in order to obtain an idea of the timing of the troughs and peaks in the beef cattle cycle.

Annual data were utilized thus eliminating seasonal and irregular fluctuations. The two components left according to Simpson and Kafka (27, p. 311) are trend and cyclical movements. Therefore in utilizing annual data it was necessary to eliminate trend only. The trend was determined by running a simple regression using X as the year and Y as the annual
price received by United States farmers or numbers of other cattle on farms. Hence, an estimate of cyclical variation was obtained by dividing annual data for each year by the trend value for that year.

Results and conclusions

The results for cyclical variation in average prices of beef received by United States farmers and the numbers of other cattle on farms on January the first are found in Figure 12.  

The figure indicates that the turning points in average prices received by United States farmers and numbers of other cattle on farms corresponded fairly well. The turning points of the two series are shown in Table 11, together with the cyclical turning points that were finally accepted.

Kohls (18, p. 121) states that the cattle cycle has averaged about fifteen years in length, with individual cycles varying from twelve to twenty years. This conflicts with the results obtained in the present study where the average cycle length was found to be 11.4 years with a range from nine to fourteen years.

---

1 Before running the regression, the annual prices were deflated using the wholesale price index (1947-1949 = 100).
2 Cyclical relatives were also calculated for consumption per capita. However the results showed only reasonable correspondence with the other two series and so it was felt that these should be excluded from this study.
3 These points were a compromise between the two series, if exact correspondence between the two was not found.
Figure 12. Cyclical relatives for average prices of beef received by United States farmers and numbers of other cattle on farms, January 1, 1910-1962.

- Average price per 10,000 lbs. received by United States farmers.
- Numbers of other cattle on farms in the United States January 1 (in 1,000 head units).
Table 11. Dates of turning points in the beef cattle cycle in the United States 1910-1962.

<table>
<thead>
<tr>
<th>Turning points of price series</th>
<th>Turning points of number series</th>
<th>Turning points finally accepted as indicating the beef cattle cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>1913</td>
<td>1914</td>
</tr>
<tr>
<td>1923</td>
<td>1918</td>
<td>1920</td>
</tr>
<tr>
<td>1928</td>
<td>1928</td>
<td>1928</td>
</tr>
<tr>
<td>1934</td>
<td>1934</td>
<td>1934</td>
</tr>
<tr>
<td>1943</td>
<td>1939</td>
<td>1939(^1)</td>
</tr>
<tr>
<td>1944</td>
<td>1945</td>
<td>1944</td>
</tr>
<tr>
<td>1951</td>
<td>1948</td>
<td>1948(^2)</td>
</tr>
<tr>
<td>1956</td>
<td>1955</td>
<td>1956</td>
</tr>
<tr>
<td>1959</td>
<td>1958</td>
<td>1958</td>
</tr>
<tr>
<td>1961</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Shepherd (25, p. 42) observes that the cycles have been getting shorter with the passage of time due to the fact that beef cattle are now being sold for slaughter at a younger age than they were several decades ago -- at one and a half to two years of age,

\(^1\) 1939 was accepted in preference to 1943 as it was felt that World War II largely accounted for high prices in 1943.

\(^2\) 1948 was accepted in preference to 1951 as the Korean War probably accounted for the abnormal prices in the latter year.
instead of two to three years. The hypothesis that the cycles are becoming shorter is supported on investigating the turning points of numbers of other cattle on farms in Table 11. However, it is invalidated if the turning points of the cycle finally accepted are used. A note of caution may not be amiss at this point. The determination of turning points is somewhat arbitrary and is largely up to individual interpretation. This is particularly the case with the turning points of the cycle finally accepted. Thus any hypotheses not substantiated in this study do not necessarily infer that they are completely invalid, but simply indicate that their validity, as far as this study is concerned, is questionable.

It was not considered necessary to examine beef cattle cycles in the state of Oregon, as it was felt that Oregon prices and numbers of other cattle on farms would very closely follow fluctuations in the national equivalents. This was supported by the fact that a correlation coefficient of 0.9999 was found to exist between Oregon and United States prices for the period 1913 to 1962, while a correlation coefficient of 0.9989 was found between numbers of beef cattle in Oregon and the nation from 1920 to 1962. Hence the beef cattle cycle determined for the United States can be considered almost exactly the same as is found in Oregon.

---

1 Prices in Oregon prior to 1913 were unavailable.
2 Numbers of other cattle in Oregon were not available earlier than 1920.
CHAPTER 4

SEASONAL VARIATION IN PRICES AND PRODUCTION OF SLAUGHTER AND FEEDER CATTLE

The simplest of the four types of fluctuations are purely seasonal movements that repeat themselves in more or less the same fashion every year. Unlike secular and cyclical movements, this type of change does not arise directly as a result of dynamic forces but instead is related to the changing seasons of the year (14, p. 220). Like the seasons, seasonal fluctuations tend to repeat themselves, though the precise seasonal pattern may change with the passage of time.

Seasonal variation is particularly important as far as agricultural products and prices are concerned, although the amount of seasonal variation in prices of several farm products has been reported to be decreasing chiefly because the amount of seasonal variation in the production of those products has been decreasing (25, p. 45).

The period selected for the following analysis was from 1951 to 1962 inclusive. The reasons behind the selection of this period were twofold:

1. Both 1951 and 1962 were peak prices in the beef price cycle.

---

1 Prices in 1963 have up to the present time (June) been falling.
2. The grading system for slaughter and beef cattle was changed in 1951, thus the utilization of years prior to 1951 would have complicated the analysis unnecessarily. 

Indices of seasonal variations in prices and production of slaughter and feeder cattle were computed, using the methodology discussed in the introduction to this study.  

**Slaughter cattle**

Although Portland terminal market is becoming somewhat less important as far as marketing of cattle and calves is concerned, it still retains a considerable proportion of the State's trade in cattle and calves (19, p. 7). Consequently, it was felt that prices at Portland for slaughter cattle should reflect fairly accurately the average price in the state of Oregon as a whole. Thus when deemed necessary, prices at Portland were used. In the following pages two or three series of relevant seasonal variation indices were computed and compared.

**Seasonal price variation for slaughter beef (all grades) in the United States and Oregon**

It can be seen from Figure 13 that seasonal price variations in Oregon and the United States for commercially slaughtered beef cattle during the period 1951 to 1962 follow very similar patterns.

---

1. See page 3. 
2. Prices used were those received by United States farmers.
Figure 13. Seasonal price variation of beef cattle commercially slaughtered (all grades) in Oregon and the United States.

- Prices received by U.S. farmers per 100 lbs.
- Prices received by Oregon farmers per 100 lbs.
apart from the fact that the range in Oregon beef prices appeared to
be higher than for the United States as a whole (i.e. 14.6 percent
compared with 11.9 percent for the latter). In both the United
States and Oregon maximum prices occurred in May and minimum
prices were found in November.

The degree of similarity between the two seasonal price
patterns was substantiated by the fact that there proved to be a
highly significant correlation coefficient of 0.9846 between the two
series.

Tests of significance for seasonal variation in the two sets
of data gave rise to the following results:

1. Oregon prices.

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of Squares</th>
<th>Mean Squares</th>
<th>F</th>
</tr>
</thead>
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<tr>
<td>Between means of years</td>
<td>11</td>
<td>2,234.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between means of months</td>
<td>11</td>
<td>153.24</td>
<td>13.9309</td>
<td>8.1639</td>
</tr>
<tr>
<td>Residual</td>
<td>121</td>
<td>206.47</td>
<td>1.7064</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>2,593.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Index values for the individual months are found in the Appendix page 135.
2 Discussion on the rationale behind the price fluctuation is to be found on pages 53 to 55.
3 Significant at the one percent level.
2. United States prices.

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between means of years</td>
<td>11</td>
<td>2511.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between means of months</td>
<td>11</td>
<td>76.66</td>
<td>6.9690</td>
<td>3.1784</td>
</tr>
<tr>
<td>Residual</td>
<td>121</td>
<td>265.31</td>
<td>2.1926</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>2853.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although both United States and Oregon prices showed significant seasonal variation, the F value for the former was a good deal lower. However, it is to be expected that seasonal prices in a state like Oregon, which is an insignificant contributor, would tend to fluctuate more than prices in the national aggregate.

Seasonal price and production variation for slaughter beef (all grades) in Oregon

Figure 14 indicates the relationship existing between the seasonal pattern in commercial slaughter in Oregon and slaughter cattle prices in Oregon.

Breimyer and Kause (4, p. 17) observe that consumer demand for meat is relatively stable season by season and that most

1 Significant at the one percent level.
Figure 14. Seasonal price variation of beef cattle commercially slaughtered (all grades) in Oregon compared with seasonal variation in numbers of head commercially slaughtered (all grades) in Oregon for 1951-1962.
consumers want to eat nearly as much meat in the summer as in the winter. In reality, this desire is in conflict with the natural pattern of calving in the spring and marketing and slaughter in the autumn. Price expresses the resistance of consumers to changes in the meat supply available. The resulting seasonal prices have led producers to amend their production patterns. Consequently, Breimeyer and Kause consider that production and marketing are now much less variable than the natural pattern, but nevertheless are still far from uniform throughout the year.

The monthly variation in cattle slaughter (all grades) in Oregon as shown in Figure 14 can be rationalized without too much difficulty. In the months of August, September and October, grass fattened cattle and cull cows off the range together with some cattle out of feedlots can account for the seasonal high. Following the peak slaughter months there is a lull during which new feeders and stockers are moved into the feedlots. Another reason for the low in December is the fact that due to holidays, slaughter days are fewer. In January slaughter rate picks up due to many farmers disposing of their animals before the tax deadline, and the fact that owing to limited time in December fewer animals are slaughtered in that month than are available. The low numbers slaughtered

1 Grass fattened cattle are becoming less important in Oregon.
2 October is the peak month for feeder and stocker marketings in Kansas. See page 62
in February can once again be explained by the shortness of the month, while the peak in March is due to farmers desiring to dispose of their slaughter animals before spring work commences. From May onwards slaughtering increases largely due to the fact that traditionally prices in Oregon were considered to be high in the summer months. Consequently producers changed their marketing patterns, but only succeeded in upsetting the previously favorable prices, and up to the present time have not readjusted their marketing patterns. It should be noted that the above is one possible explanation for seasonal variation in production. However, factors other than those mentioned could be important, but the scope of this study does not permit further investigation. The above reasoning is simply meant to indicate that the seasonal variation in production can be rationalized.

On turning to prices, Breimyer and Kause (4, p. 17) state that variations in production and supply that remain are primarily

---

1 Breimyer and Kause (4, p. 26) rationalize the fluctuation in cattle slaughter (all grades) in the United States by discussing changes in the composition of cattle slaughter throughout the year. Briefly, the slaughter of steers is at its lowest point in the fall, when cattle marketings are at a peak, while its own peak is in March to May. Heifer slaughter usually reaches a peak in January while cow slaughter is highly seasonal giving total cattle slaughter a seasonal swing from a fall high to a late winter - early spring low. Unfortunately it was not possible to rationalize on a similar basis in Oregon as data on numbers of cows, heifers and steers slaughtered were not available. A similar pattern may exist in Oregon but no statistical proof can be offered at this point.
responsible for the seasonal fluctuation in prices. This may be true with reference to prices and production of individual grades of slaughter cattle. However, in this study it was found that the expected inverse relationship between prices and production in October, November and December was found to be lacking. In fact there was a correlation coefficient of only 0.1795 between average prices received by United States farmers for beef and numbers of head slaughtered.

Several possible reasons can be advanced for the lack of a counter seasonal pattern between prices and numbers of head slaughtered.

1. Farmers due to climatic conditions and the comparatively long production periods of beef cattle are relatively unresponsive to seasonal price changes, which are influenced by other factors besides production, for example, changes in consumption demand, supplies of competing meats, etc.

2. The supply of fed cattle throughout the year is very likely made up of shifting composition of grades, and types of beef animals. These could cause prices and numbers of head

---

1 See footnote on page 53.
slaughtered to move together.  

3. Another possible reason, largely linked to two, is that average prices received by farmers is technically made up of slaughter and feeder prices. On an annual basis, feeder and stocker animals constitute a very low percentage of total number of cattle passing through the markets and thus have little influence on annual price. However, during any one month the numbers of feeders marketed could conceivably make up quite a high proportion of the total number of cattle marketed. This is likely to be especially true in the early fall when movements of feeder cattle are greatest. High movements at such a time could help account for low prices received by farmers for their stock.

The range or amplitude of the price and production series in Oregon proved to be very different. The range in numbers of head slaughtered was 25.6 percent while in the case of average prices received by farmers, it was only 14.6 percent. However, both series showed significant seasonal variation as the following tests show:

---

1 For example, at Chicago, 1939 to 1950, Cox Eisenach and Mitchell (6, p. 27), showed that cows slaughtered in early fall contributed a high percentage of total cattle slaughter at that time. Grades and hence prices of cows (4, p. 7) are usually poor thus tending to drag the average price received by United States producers downwards. After November steer slaughter picks up and as they grade better and command higher prices than cows, they thereby succeed in pulling up average prices received by farmers. Thus prices and production could tend to move together.

2 See page 62.
1. Seasonal price variation in Oregon

\[ F = 8.1639 \]

2. Seasonal variation in the numbers of head slaughtered in Oregon.

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between means of years</td>
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<td>1379.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between means of months</td>
<td>11</td>
<td>366.07</td>
<td>33.2791</td>
<td>16.6537 ³</td>
</tr>
<tr>
<td>Residual</td>
<td>121</td>
<td>241.80</td>
<td>1.9983</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>1987.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the above results and Figure 14, there appears to be less fluctuation in prices received by farmers than in production. It is difficult to find a reason for this as cold storage constitutes less than one percent of total production. Another possible but not very likely reason is that seasonal trends in demand are more parallel to those in slaughter than is generally believed (23, p. 10).

1 For details of this test see page 49.
2 Significant at the one percent level.
3 Significant at the one percent level.
It may not be amiss to point out that the winter high in beef prices (i.e. March and May) does not necessarily mean that producers will obtain maximum net returns by planning to market beef cattle in late winter and early spring. Seasonal patterns in feed costs and efficiency of gains also influence net returns to beef producers.

Seasonal price variation of specified grades of slaughter cattle in Oregon

Cattle are sold at all ages and all degrees of finish. Their finish and grade are related to how much feeding of grain and supplements they receive.

The grading system was amended in March 1951 (30, p. 1) giving rise to seven grades of slaughter cattle, these being prime, choice, good, commercial (which became standard in 1956), utility, cutter, and canner. The highest federal grade for slaughter cows is choice, but in reality few cows grade higher than commercial. Steers and heifers that are given no fattening rations grade utility or commercial, or sometimes as high as good.

Feeding usually begins in the fall when cattle are marketed off grass (4, p. 3). Cattle fed a short time usually grade no higher than good, and a longer feeding period is necessary to make choice grade, while prime is attained only after a prolonged period of feeding. Therefore as the supply of the respective grades is related to the length of time spent on feed, their price trends differ in the same way.
For the purposes of illustrating seasonal price variation of different grades in Oregon, choice steer and good heifer prices at Portland were analyzed, giving rise to the results shown in Figure 15. Both price series show the same general seasonal patterns which can be rationalized on the basis of the above remarks. If numbers of choice steers (and good heifers), marketed show a counter seasonal pattern to the price of choice steers (and good heifers), then the heaviest marketing periods can be considered to be December through to February for good heifers and December to May for choice steers. This is reasonable enough in that the cattle would go on feed in the early fall and would be ready for slaughter after four to five months feeding. Their prices then trend upwards during the summer months presumably due to lighter marketings. The peak and low prices for choice steers and good heifers differed, being July and May respectively for the peaks, while minimum prices were in February and December respectively.

The range of prices was higher with good heifers, where it was 9.5 percent, while choice steers showed an amplitude of 5.6 percent. Both price series showed significant seasonal price variation as the results of the following tests showed.

---

1 For indice values of the individual months of the two series, see the Appendix page 135.
2 Unfortunately, it was not possible to verify this due to unavailability of relevant data.
Figure 15. Seasonal price variation of choice steers and good heifers at Portland (Oregon). 1951-1962.
1. Choice steer seasonal price variation at Portland

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between means of years</td>
<td>11</td>
<td>2312.49</td>
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</tr>
<tr>
<td>Between means of months</td>
<td>11</td>
<td>96.60</td>
<td>8.7820</td>
<td>5.5022</td>
</tr>
<tr>
<td>Residual</td>
<td>121</td>
<td>193.13</td>
<td>1.5961</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>2602.23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Good heifer seasonal price variation at Portland

Analysis of variance

<table>
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<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean square</th>
<th>F</th>
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</thead>
<tbody>
<tr>
<td>Between means of years</td>
<td>11</td>
<td>2632.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between means of months</td>
<td>11</td>
<td>73.16</td>
<td>6.6506</td>
<td>3.4069</td>
</tr>
<tr>
<td>Residual</td>
<td>121</td>
<td>236.21</td>
<td>1.9521</td>
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</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>2941.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Significant at the one percent level.
Stocker and feeder cattle

According to Breimyer and Kause (4, p. 16) prices of feeder livestock are even more closely associated with the grazing season than are prices of slaughter stock. This is substantiated by the results shown in Figure 16 for stocker and feeder steers at Kansas City. Prices tend to be low in the fall when herds must be reduced as the grazing season ends. Consequently there is a tremendous peak in numbers of head of feeder and stocker steers placed on the market in October. Conversely, prices are higher in the spring when greening of the grass brings a need for restocking the ranges. However, it will be observed from Figure 16 1 that prices vary little throughout the year while numbers show a high variation. This was supported by the results of the following tests of significance.

1. Seasonal variation in feeder and stocker steer prices at Kansas City 1951 to 1962.

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
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<tr>
<td>Between means of years</td>
<td>11</td>
<td>2,716.72</td>
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<td>Between means of months</td>
<td>11</td>
<td>149.59</td>
<td>13.5991</td>
<td>0.0032</td>
</tr>
<tr>
<td>Residual</td>
<td>121</td>
<td>714,296.46</td>
<td>5,903.2765</td>
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</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>716,162.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Seasonal relatives for the individual months are shown in the Appendix page 135.
Figure 16. Seasonal variation in prices and numbers of head of feeder and stocker steers marketed at Kansas City, 1951-1962.

- - - Seasonal variation in numbers of feeder and stocker steers (all weights), 1951-1961.
- - - Seasonal price variation of feeder and stocker steers, 1951-1962.
2. Seasonal variation in numbers of feeder and stocker steers marketed at Kansas City 1951 to 1961.

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean square</th>
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<td>Between means of years</td>
<td>10</td>
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<tr>
<td>Between means of months</td>
<td>11</td>
<td>5,764,473,250</td>
<td>524,043,022</td>
<td>19.2536</td>
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<tr>
<td>Residual</td>
<td>110</td>
<td>2,993,963,781</td>
<td>27,217,852</td>
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</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>15,614,112,161</td>
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<td></td>
</tr>
</tbody>
</table>

Therefore, as expected, only numbers of feeder and stocker steers showed significant seasonal variation. The apparent discrepancy in variation between prices and marketings of feeder and stocker steers can be explained partly by different intensities of demand for feeder and stockers during the course of any one year. In the fall the demand for feeders and stockers to place in feedlots is very high, with the result that in spite of the large supply of animals available at that time, prices of feeders and stockers are only slightly depressed. Conversely, in the spring there is a relatively low demand for feeders and stockers for feedlots plus some demand for

1 Significant at the one percent level.
young cattle to restock the ranges. However, compared with the fall the total demand for feeders and stockers is much lower and is partially offset by an increase in marketings at that time. The net result is that prices are above the annual average but not markedly so.

Unfortunately, owing to unavailability of data it was not possible to carry out a similar analysis for Oregon. However, it can be hypothesized that similar seasonal patterns for production and prices of feeders and stockers exist in Oregon. This is supported by the fact that in California during the period 1951 to 1961 a similar seasonal pattern of movement of feeders and stockers was found to exist, as at Kansas City. For example, October was once again the peak month accounting for 19.88 percent of the total numbers of feeder and stocker cattle shipped in for fattening in feedlots (33, p. 10).
CHAPTER 5

FACTORS INFLUENCING THE ANNUAL PRICE OF SLAUGHTER BEEF CATTLE AT THE SLAUGHTER HOUSE LEVEL

In this chapter, theoretical demand and supply equations were developed at the slaughter house level, thereby giving rise to a farm price equation for slaughter beef, which was estimated using stepwise regression.

The theoretical development of the slaughter beef market

In the slaughter beef market it appears that three different marketing levels can possibly be differentiated, from the time the live animal is taken to the market, to the time it is sold as meat to consumers.

Figure 17 on the following page indicates that as far as the farmer is concerned, the fattened animal is an end product, while to the wholesaler who slaughters and processes the animal, it is simply an input. The product produced by the wholesaler is processed meat and by-products to which the retailer adds services such as packaging and delivery, thereby giving rise to the product that finally reaches the consumer.

It would appear also from Figure 17 that the demand for beef at the slaughter house level is in effect a derived demand for beef at the consumer level. Consequently, factors determining demand at
the consumer level, such as income and pork supplies could con-
ceivably become relatively unimportant in determining demand at
the slaughter house level.

Figure 17. Marketing levels of slaughter beef.

Buyers

Consumers ↔ Retail price → Retailers

Retailers ↔ Packing-house price → Wholesalers

Wholesalers ↔ Farm price → Farmers

(packing and slaughter houses)\(^1\)

Demand for slaughter beef
cattle at the slaughter
house level

Demand for a factor of production

In economic theory, once a production function has been
established and the price of the output is known, it is then possible
to determine the optimum economic price for the input being in-
vestigated. This is found by equating the derivative of total value

\(^1\) It is assumed that slaughtering and packing is carried out by the
same firm.
product to the derivative of total factor cost (16, p. 99).

In the preceding section it was shown that as far as the wholesaler is concerned, beef cattle entering the slaughter house from farms constitute an input. Consequently, to the wholesaler, beef cattle are simply a factor of production which is essential in producing the final product, i.e. processed meat.

Therefore the optimum profit point for the input can be rewritten as follows:

\[ VMP = P_o \cdot MPP_F = P_F \]

where:

- \( P_o \) = price of product (i.e. price of beef and by-products at the consumer level).
- \( q_F \) = numbers of beef cattle entering slaughtering houses.
- \( P_F \) = cost of the input of beef cattle (i.e. price of beef at slaughter house level).
- \( VMP \) = value of marginal product
- \( MPP_F \) = marginal physical product of processed beef and by-products with respect to the input of beef cattle.

**Variables influencing factor demand**

In this section it is intended to derive a demand equation for beef cattle at the slaughter house level, which in this context is considered to be a factor of production.
A possible production function for finished beef and by-products could be:

\[ O = f(q_F, z_1 \ldots z_n, x_1 \ldots x_m) \]

where:
- \( O \) = output of processed beef and by-products.
- \( q_F \) = numbers of beef cattle.
- \( z_1 \ldots z_n \) = other variable factor inputs such as labor and water.
- \( x_1 \ldots x_m \) = fixed factors such as buildings and equipment.

As mentioned previously, output actually consists of two products, namely processed beef and by-products. This output can be written as:

\[ O = aQ_B + (1-a)Q_T \]

where:
- \( a + (1-a) = \) one , This relationship is necessary in order to establish that the ratio of processed beef to by-products is constant for any beef carcass.
- \( Q_B \) = quantity of processed beef.
- \( Q_T \) = quantity of by-products.

It should be noted that the quantities of processed beef and by-products produced will depend on the quantities used of those factor inputs specified in the production function (i.e. equation (3)).

Total cost of the output will depend on the cost per unit of each of the inputs times the quantities used of those inputs.
(5) \[ T.C. = q_F P_F + z_1 P_{z_1} + \ldots + Z_n P_{z_n} + x_1 P_{x_1} + \ldots + x_n P_{x_n} \]

where:

- \( P_F \) = cost per animal to the slaughterer (i.e. price received by farmers).
- \( P_{z_1} \) = cost per unit of the variable resource \( z_1 \).
- \( P_{z_n} \) = cost per unit of the variable resource \( z_n \).
- \( P_{x_1} \) = cost per unit of the fixed input \( x_1 \).
- \( P_{x_n} \) = cost per unit of the fixed input \( x_n \).

Similarly total revenue derived from the products produced can be found by multiplying the quantities of the products produced by the price per unit of those products.

(6) \[ T.R. = \Omega \left[ a P_B + (1-a) P_T \right] \]

where:

- \( P_B \) = price of beef at retail.
- \( P_T \) = price of by-products at retail.

Thus the returns from the slaughtered animals at the retail level are derived from two sources, namely beef and by-products.

Demand equations exist at the retail level for beef and by-products. The supply of beef originates from domestic and foreign sources. Beef from foreign sources is considered to be closely related to that from domestic sources. It is reasonable to assume that as the price of domestic beef rises relative to imported beef, then the latter will be substituted for the former. Thus the demand for
domestic beef can be considered to be a function of the price of imported beef. Extent of this dependence is of course an empirical question. It would therefore seem reasonable to assume that two fairly well differentiated markets exist for domestic and imported beef, thus giving rise to different prices for the two products.\(^1\)

Two demand equations for processed beef can now be derived.

\[
(7) \quad Q_B^D = 1(P_B, P_I, Y, P, G, Q_C, u_1 \ldots u_n)^2
\]

\[
(8) \quad Q_B^{ID} = 1'(P_B, P_I, m_1 \ldots m_n)
\]

where:

- \(Q_B^D\) = quantity of domestic processed beef demanded at the retail level.
- \(P_B\) = price of domestic beef at retail level.
- \(P_I\) = price of imported beef at retail level.
- \(Q_B^{ID}\) = quantity of imported processed beef demanded at the retail level.
- \(Y\) = per capita disposable income.
- \(P\) = population.

---

\(^1\) It would also be possible to approach this from the standpoint of assuming that the two products are identical, thereby indicating that only one market exists and only one price prevails. However, the above analysis does emphasize to a greater extent the dependence between the two beef sources and does not necessitate the consideration of a supply equation for imports which would be imperative if the products were considered identical.

\(^2\) The rationale behind the inclusion of the specified variables is considered on pages 73 to 79 of this study.
\( G \) = general price level.

\( Q_C \) = supplies of competing meats.

\( u_1 \ldots u_n \) = other factors such as climate, consumption patterns, etc.

\( m_1 \ldots m_n \) = other factors such as quality of imported meat, utility preference, etc.

Equation (8) can be written as:

\[
(9) \quad P_t = P_B, Q_B^{ID}, m_1 \ldots m_n
\]

The price of imported beef at retail level appears in equation (7), which can therefore be rewritten as follows:

\[
(10) \quad Q_B^D = k(P_B, Q_B^{ID}, Q_C, Y, P, G, u_1 \ldots u_n, m_1 \ldots m_n)
\]

A demand equation for the other product, namely by-products, is much easier to derive. Significant imports of by-products are unlikely due to high costs of transportation and their relatively low value. A possible demand equation for by-products is given below.

\[
(11) \quad Q_T^D = h(P_T, w_1 \ldots w_r)
\]

where:

\( Q_T^D \) = quantity of by-products demanded at the retail level.

\( w_1 \ldots w_r \) = other factors such as numbers of hogs, quantities of substitute high protein feeds, etc.

With the information now presented, it is possible to find the profit resulting from producing processed beef and by-products.
Profit = \( \mathcal{T} = T.R. - T.C. \)

Substituting in equations (5) and (6) for total revenue and total costs gives the following results:

\[
(12) \quad \mathcal{T} = O \left[ aP_B + (1-a)P_T \right] - q_FP_F - z_1p_{z_1} \ldots z_np_{z_n} - x_1p_{x_1} \ldots x_np_{x_n}
\]

\[
= \left[ aQ_B + (1-a)Q_T \right] \left[ aP_B + (1-a)P_T \right] - q_FP_F - z_1p_{z_1} \ldots x_np_{x_n}
\]

\[
= a^2Q_BP_B + a(1-a)Q_BP_T + a(1-a)Q_TP_B + (1-a)^2Q_TP_T - q_FP_F - z_1p_{z_1} \ldots x_np_{x_n}
\]

To find the optimum economic profit point expressed in equation (2), it is necessary to find the partial derivative of profit with respect to the numbers of beef cattle entering the slaughter houses.

\[
(13) \quad \frac{\partial \mathcal{T}}{\partial q_f} = a^2 \left( \frac{\partial Q_B}{\partial q_f} \right) P_B + a(1-a) \left( \frac{\partial Q_B}{\partial q_f} \right) P_T + a(1-a) \left( \frac{\partial Q_T}{\partial q_f} \right) P_B + (1-a)^2 \left( \frac{\partial Q_T}{\partial q_f} \right) P_T - P_F
\]

The partial derivative of profit with respect to numbers of cattle taken to slaughter houses is set equal to zero, as at this point profit will be maximized with respect to input of cattle numbers.
(14) \[ P_F = P_B \left[ a^2 \left( \frac{\partial Q_f}{\partial q_f} \right) + a(1-a) \left( \frac{\partial Q_f}{\partial q_f} \right) \right] + P_T \left[ a(1-a) \left( \frac{\partial Q_T}{\partial q_f} \right) + (1-a)^2 \left( \frac{\partial Q_T}{\partial q_f} \right) \right] \]

\[ \frac{\partial Q_f}{\partial q_f} = \text{marginal physical product of processed beef output with respect to input of cattle numbers.} \]

\[ \frac{\partial Q_T}{\partial q_f} = \text{marginal physical product of by-product output with respect to input of cattle numbers.} \]

From equation (14) it is possible to obtain a function for the price of beef animals at slaughter house level.

(15) \[ P_F = k_1(P_T, P_B) \]

On substituting equation (10) for \( P_B \) and rearranging equation (15):

(16) \[ Q_B^D = k_2(P_F, Q_B^{ID}, Q_C, Y, P, G, P_T, u_1 \ldots u_n, m_1 \ldots m_n) \]

Equation (16) is the demand equation for the input of beef cattle numbers, and in fact is the demand equation used in a subsequent section.

**Rationale behind the variables in the demand equation**

In equation (15) the cost of the input of slaughter beef animals is stated as a function of the price of beef and by-products at the retail level. The higher the price that is obtained for beef and by-products at the retail level, the higher will be the price that the slaughterer is prepared to pay for the slaughter cattle. Thus a
direct relationship exists between the price of beef at the retail level and the price at the slaughter house level. Therefore, in rationalizing the presence of the variables in the following paragraphs, the price of beef can be considered the price at retail or at the slaughter house level.

1. Demand for domestic beef. According to the law of demand an inverse relationship exists between the price and quantity demanded of a particular product. In the case of most agricultural products demand tends to be relatively price inelastic. Hence with a given demand function, for an increase in price, quantity taken of a product falls only a little, while a drop in price results in a relatively small increase in quantity taken. In the case of beef, however, substitute meats such as pork and poultry make the demand curve for beef somewhat more elastic. Nevertheless a negative relationship can be expected to exist between the price of domestic beef and the quantity taken of domestic beef. In fact quantity taken of domestic beef is likely to have a significant influence on the price of domestic beef.

2. Demand for imported beef. In the late nineteenth century and the early part of this century, the United States was a leading exporter of beef and, in fact, in 1901-1902 accounted for nearly eight percent of the total production (6, p. 12).

However since 1912, apart from a small period following World War II, the United States has become a small importer of
beef, accounting for about two percent of United States production in the early 1950's. The importation of beef will have a small but discernable effect on the demand for and hence the price of domestic beef. It was hypothesized in the previous section that the domestic and imported beef markets were largely but not completely independent of each other. According to this reasoning an inverse relationship can be expected to exist between imports of beef and the price of domestic beef.

However, a positive relationship could be brought about by interaction between the independent variables. The presence of non zero covariance between the independent variables is known as multicollinearity. Meat consumption tends to rise with an increase in disposable income per capita \(^1\) and as a result it would seem that demand for imported beef could increase and thereby offset the negative relationship existing between price of domestic beef and the demand for imported beef.

3. Population. Population is a reasonable variable to include as it is one of the determinants of demand. The elasticity of demand with respect to population is plus one. Therefore an increase in population will bring about an equal increase in the numbers of consumers, which will result in a proportionate increase in the demand for beef, assuming that tastes and preferences for beef have not correspondingly declined.

\(^1\) See footnote on page 77.
4. Price of by-products. By-products are considered to be everything of value on the killing floor, other than dressed meat. By-products, which can be divided into two classes, edible and non-edible, account for one sixth of the liveweight of beef steers and include three pounds of fresh meat, three pounds of edible oils, six pounds of hide, and five pounds of other inedible products per hundred pounds of live animal. The value of these by-products average between ten and 15 percent of the total value of the animal at the wholesale level (2, p. 10).

Therefore the reason for the inclusion of the variable is largely because by-products are of value to the packer, and therefore the revenue he receives for these by-products will influence to some extent the price he is willing to pay for the live animal. Thus it would seem that the slaughterer will be willing to pay more for the live animal if the revenue from selling the by-products simultaneously increases. Consequently, according to this hypothesis a positive relationship should exist between the cost of the live animal and the returns from selling the by-products.

5. The general price level.

The price level represents, to a certain extent, the relationship between commodities and services on one hand and money and credit on the other. Price level is influenced within a country by the relationship between money or purchasing power in the hands of consumers, and the goods and services they seek to buy with that money. (6, p. 10)

Prices of most agricultural commodities in the United States
tend to respond to changes in the price level. As would be expected
the annual price of beef received by United States farmers tends to
move up and down with annual fluctuations of the price level. There-
fore the price level can be expected to be a significant factor in
determining the annual price of beef cattle received by United States
farmers in monetary terms.

6. Disposable income per capita. As disposable income in-
creases, total meat consumption tends to increase, but the composi-
tion of the meats consumed is changed. Beef is generally considered
to have a relatively high income elasticity when compared with most
other meats. Consequently as disposable income increases the
consumption of beef can be expected to increase more than the
consumption of other meats which have relatively low income
elasticities.

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1 The variable general price level could also be introduced through
the retail demand function, i.e. consumers react to real changes in
income and prices, not money changes. However, it has been
hypothesized that consumers are more responsive to money changes
rather than real changes.

2 Some idea of the relative movements in meat consumption can be
gleaned from the following, although this data should not be used to
infer anything concerning income elasticities:

<table>
<thead>
<tr>
<th>Year</th>
<th>Disposable income per capita (dollars)</th>
<th>Meat consumption (red and white) per capita (pounds)</th>
<th>Consumption per capita of different meats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Beef (lbs)</td>
<td>Poultry (lbs)</td>
</tr>
<tr>
<td>1950</td>
<td>1.359</td>
<td>157.4</td>
<td>63.4</td>
</tr>
<tr>
<td>1955</td>
<td>1.660</td>
<td>183.1</td>
<td>82.4</td>
</tr>
<tr>
<td>1960</td>
<td>1.934</td>
<td>194.6</td>
<td>85.2</td>
</tr>
</tbody>
</table>

Poultry consumption rose a great deal in the ten year period, but it
should be borne in mind that broiler production was a comparitively
new enterprise prior to 1950, which would help account for the
rapid increases in consumption in recent years.
7. Quantities of competing meats. Types of meat are often divided into two classes, red and white meat. Red meat is usually considered to consist of mutton, beef, veal, and pork, while poultry meat constitutes the bulk of the white meat class. Red and white meats are often considered to be non-competitive with each other. However, in this study it was felt that broiler consumption would affect to some extent the demand for beef as there is a limit to the total amount of meat a person will consume, although as indicated previously total meat consumption per capita tends to rise a little over time as a result of increases in disposable income per capita.\(^1\) In addition pork, mutton, lamb, and veal consumption will also affect the demand for beef. However, mutton, lamb, and veal account for an ever decreasing fraction of total meat consumption and therefore could possibly be neglected without adversely affecting the empirical results. The supplies of competing meats, notable pork and poultry, could be expected to bear an inverse relationship with the demand for and the price of beef. However, the inverse relationship may be offset by the fact that the demand for poultry, beef, but possibly not pork, tends to increase with an increase in income.\(^1\) Consequently, due to the existence of multicollinearity between the independent variables the inverse relationship could possibly be negated, giving rise to a positive relationship.

\(^1\) See footnote on page 77.
The supply of slaughter cattle at the slaughter house level

Variables affecting the supply of slaughter cattle

Unlike the demand side of the market, the supply of slaughter cattle by farmers was considered initially exogenous or pre-determined. In other words the decision of farmers to place a given supply on the market is determined by factors antecedent to the period being considered and by factors outside the market.

The following equations were considered to be of relevance in determining the supply of beef slaughter cattle:

\[ Q_{BT}^S = f(N_{CFt}, K_{Ft}, R_t, R_{t-1}) \]

\[ N_{CFt} = g(C_{t-1}) \]

where:

- \( Q_{BT}^S \): numbers of slaughter beef cattle supplied.
- \( N_{CFt} \): numbers of cattle on feed January 1.
- \( K_{Ft} \): numbers of other cattle on farms January 1.
- \( R_t \): condition of cattle on range in the current year.
- \( R_{t-1} \): condition of cattle on range in the preceding year.
- \( C_{t-1} \): size of corn crop the previous year.

Rationale behind the inclusion of the variables in the supply equation

Three factors were considered of major importance in determining beef production in any given year.
1. Numbers of other cattle on farms. "Other" cattle constitute all cattle, except those kept exclusively for dairy purposes. It would appear reasonable to hypothesize the higher the numbers of other cattle there are, the greater will be the supply of slaughter cattle. Therefore, a positive or direct relationship can be expected to exist between numbers of other cattle and the numbers slaughtered.

2. Condition of cattle on range. The condition of cattle on range the preceding year can be expected to have some influence on the quantity of beef produced in the current year. The condition of cattle on range, which is to some extent dependent on the condition of the range itself and of the inherited characteristics of the animals, will determine when those animals are ready to be fed in feedlots, where they remain for a period of 120 to 150 days. Consequently the better condition the animals are in the previous year, the higher will be the numbers of animals ready for feedlots and therefore greater will be the quantity of beef supplied in the current year.

In addition, as the average period spent in the feedlots is only four to five months, it would appear that the condition of cattle on the range in the current year will also have some influence on slaughter beef cattle produced in the current year.

3. Numbers of cattle on feed January the first. These will

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1 Information supplied by S. Marks, Extension Agricultural Economist, Oregon State University.
once again influence the quantity of beef produces and will bear a
direct relationship with it. This is rational as almost all the beef
produced passes through feedlots. January the first is not selected
for any special reason, apart from the fact that limitations on the
availability of data would make the adoption of any other time or
time period impracticable.

The size of the corn crop the previous year will only affect
beef production indirectly inasmuch as it will influence the numbers
of cattle on feed in the current year, \(^1\) which in its turn directly
influences beef cattle production. It is reasonable to hypothesize
that the higher the corn crop was the previous year, the higher will
be the numbers of cattle placed on feed in the current year, as corn
accounts for a high proportion of the feed fed in feedlots.

4. Price of beef slaughter cattle. Normally the price of a
product would be considered to be an important factor in determining
the quantity supplied in a given market.

However, in the case of beef cattle it was felt that owing to
the long production period of beef coupled with a lack of alternative
outlets for the animals, that the farmer cannot consider current
price an important factor in determining how much he will place on

\(^1\) Kohls, R.L. (17, p. 15) found that the size of the corn crop
explained 66 percent of variation in numbers of cattle on feed
during the period 1931 to 1947, whereas by holding range con-
ditions constant, Cox, et al. (6, p. 9) found that corn production
explained 76 percent of the variation in number of cattle on feed
1931 to 1950.
the market, at least in the short run. Also tradition and difficulty of forecasting prices two years\(^1\) hence will tend to keep the beef producer in business in the long-run, providing none of the three factors mentioned previously are adversely affected.

**Equilibrium point**

An equilibrium market price under conditions of perfect competition is found at the intersection of the aggregate demand and supply schedules. In reality, however, an equilibrium is seldom if ever attained although there is a marked tendency to move towards this point. In this analysis it was assumed that perfect competition\(^2\) exists in the beef slaughter market and therefore market price is determined at the point where the total quantity demanded of beef equals the total quantity supplied.

Figure 18 brings together in diagram form the demand (16) and supply (17) equations derived in previous sections, in order to determine the farm price of beef at the slaughter house level.

It is now possible with the aid of the preceding analysis to set up a model showing the main factors that influence the annual

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1. A steer may take up to two years before it is ready for slaughter.
2. This assumption does not detract from the value of this analysis as agriculture is usually considered to have perfect competition characteristics such as large numbers of buyers and sellers, free entry and exit of producers, homogenous products, etc. Therefore, at the slaughter house level the assumption of perfect competition is not unrealistic.
Figure 18. Diagram showing factors important in determining the annual price of slaughter beef (all grades) received by U.S. farmers.
price of beef received by United States farmers.

Equation 1. Demand for beef by slaughterer.

\[ P_{Ft} = k_3(Q_{Bt}^D, Q_{Bt}^{ID}, Q_{Ct}, Y_t, P_t, G_t, P_{Tt}) \]

Equation 2. Supply of beef by farmers.

\[ Q_{Bt}^S = f(N_{CFt}, K_{Ft}, R_{t-1}, R_t) \]

Equation 3.

\[ N_{CFt} = g(C_{t-1}) \]

Identity.

\[ Q_{Bt}^S = Q_{Bt} = Q_{Bt}^D \]

Derivation of the price equation

The variables can now be classified as exogenous or endogenous.

Table 12. Exogenous and endogenous variables of a model used for investigating the factors important in determining the farm price of beef.

<table>
<thead>
<tr>
<th>Equation</th>
<th>Endogenous variables</th>
<th>Exogenous variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( P_{Ft} )</td>
<td>( Q_{Bt}, Q_{Bt}^{ID}, Q_{Ct}, Y_t, G_t, P_{Tt} )</td>
</tr>
<tr>
<td>2</td>
<td>( Q_{Bt} )</td>
<td>( N_{CFt}, K_{Ft}, R_{t-1}, R_t )</td>
</tr>
<tr>
<td>3</td>
<td>( N_{CFt} )</td>
<td>( C_{t-1} )</td>
</tr>
</tbody>
</table>


As can be seen in Table 12, an estimate of the numbers of cattle on feed January the first \( (N_{CFt}) \) can be obtained from the size of the corn crop the previous year \( (C_{t-1}) \). However, in equation two, numbers of cattle on feed can be considered an exogenous variable since it was itself derived from an exogenous variable. The estimate or actual value of the numbers of cattle on feed could be used for this variable. However, the use of the estimate would increase the error in estimating the quantity of beef produced by the farmer \( (Q_{Bt}^S) \), as there has already been an error in estimating the numbers of cattle on feed. Thus in estimating equation two, equation three becomes unnecessary.

Exactly the same reasoning can be applied to the equilibrium quantity of beef in equations two and one. Therefore, equation can also be dispensed with, leaving one equation to be estimated. This in fact is the price equation and can be written as follows:

Equation 4. The price equation.

\[ P_{Ft} = h_1(Q_{Bt}, Q_{Ct}, Y_t, G_t, P_t, P_{Tt}, Q_{ID}^B) \]

As this price equation consists of only one endogenous variable and is exactly identified, the method of least squares can be used in estimating the farm price of slaughter beef.
Empirical results

The estimating equation for price

Oregon and United States annual prices

For many years 1913-1962 it was found that a correlation coefficient of 0.9999 existed between Oregon and United States annual prices received by farmers per hundred pounds of slaughter beef, where Oregon prices were considered the dependent variable. This high correlation means that any equation with Oregon slaughter prices would have to include as an independent variable United States slaughter prices. However, the high correlation between the two price series would smother any other factors that might help determine Oregon prices and so it was felt that there was little object in deriving a price equation for Oregon slaughter prices. Consequently, the price equation was derived for the United States only, on the assumption that this would also give a satisfactory indication of Oregon prices.

Time period selected

Data were collected for the United States from secondary sources, for the years 1947 to 1962 inclusive. It was not possible to go back further than 16 years due to the abnormal conditions of war and rationing that existed prior to 1947.

Modifications to the price equation

A few modifications were carried out on the price equation
below, which was theoretically derived in the preceding sections of this chapter.

\[ P_{Fr} = h_1(Q_{Bt}, Q_{Ct}, Y_t, G_t, P_t, P_{Tt}, Q_{ID}) \]

Population \((P_t)\) and general price level \((G_t)\) were incorporated into the other variables, by adjusting quantities to a per capita basis and expressing prices in real terms. The reason for this was to increase the residual degrees of freedom which were low due to the large number of independent variables and the relative shortness of the period which was only 16 years.

Therefore the price equation actually estimated was as follows:

\[ Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 \]

where:

- \(Y\) = average annual price per 100 pounds received by United States farmers \(^1\) in real terms.
- \(X_1\) = by-product allowance per 100 pounds for choice steers in real terms.
- \(X_2\) = disposable income per capita in real terms.
- \(X_3\) = total liveweight in pounds of beef commercially slaughtered per capita.

---

1 This statistic is invariably considered to be the price received by United States farmers for slaughter beef and was used in this context, as far as the present study was concerned. In actual fact it does include some feeders and stockers, but as they account for such a small proportion of the total numbers of animals marketed they can be considered to be insignificant in determining the value of the statistic.
Concerning the expected signs to be found on the parameters these were fully discussed in an earlier section. In summary all the independent variables except total liveweight in pounds of beef and possibly pork commercially slaughtered per capita can be expected to have positive values. The remaining one or two variables should have negative values.

A stepwise regression was employed on the price equation specified above.

Results and implications of the stepwise regression

The following regression model was selected on the basis of the specifications discussed in the introduction to this study.

\[
\hat{Y} = 19.41227 + 1.66456 X_1 + 0.01085 X_2 - 0.19481 X_3
\]

\[
(8.79735)^4 \quad (6.45309)^4 \quad (11.41308)^4
\]

1. See pages 73 to 78 of this study.
2. Detailed results of the stepwise regression are to be found in the Appendix page 136.
3. See page 2.
4. The figures in parenthesis are T-ratios of the regression. All the regression coefficients were significant at the one percent level.
\[ R = 0.99352^1 \]
\[ R^2 = 0.98708^2 \]
\[ \text{Syx.} = 0.58486 \]

where:

\[ \hat{Y} = \text{annual price per 100 pounds received by United States farmers for slaughter beef in real terms.} \]

\[ X_1 = \text{by-product allowance in dollars per 100 pounds in real terms for choice steers.} \]

\[ X_2 = \text{disposable income in dollars per capita in real terms.} \]

\[ X_3 = \text{total liveweight in pounds of beef commercially slaughtered per capita.} \]

It will be observed that independent variables \( X_4, X_5, \) and \( X_6 \) are not present in the estimating equation accepted. The reason for this is that the addition of the aforementioned variables increased the standard errors of estimate thereby detracting from the value of the regression equation.

The results of this estimating equation can be summarized as follows:

1. A one dollar increase in by-product prices per 100 pounds in real terms will result in an increase in the real farm price per 100 pounds of beef, of $1.66, assuming that the other variables remain constant. This at first glance appears difficult

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1 Significant at the one percent level.
2 A coefficient of multiple determination of 0.98708 means that the three independent variables explain 98.708 percent of the variation in the price of beef at the slaughter house level.
to rationalize. However, a correlation coefficient of 0.7069\(^1\) was found to exist between the by-product allowance and the price of round steak at the retail level. Therefore, retail prices and by-product allowance move together. As a result the slaughterer is prepared to pay more for the input of beef cattle when the price of by-product increases, since retail beef prices increase at the same time.

2. A one dollar increase in real disposable income per capita will increase the real farm price per 100 pounds by one cent, assuming that the other variables remain constant.

3. A decrease of one pound in total liveweight of beef commercially slaughtered per capita will increase the real farm price of beef per 100 pounds by 19 cents.

It should be noted that the model included two implicit variables, namely population and the consumer price index. As was discussed earlier, the reason for incorporating them implicitly rather than explicitly was due to the small number of degrees of freedom imposed by the fact that observations could only be taken from 16 years.

The significance of the by-product allowance tends to enhance the hypothesis that has been put forward concerning the fact that slaughtering plants cover their costs by selling the processed beef

\(^{1}\) Significant at the 2.5 percent level.
and make their profit from the sale of the by-products of the animals. Consequently, the price they are willing to pay for the animals is influenced to a considerable extent by the amount of revenue they will obtain from the sale of by-products.

Both real disposable income per capita and total liveweight commercially slaughtered per capita were expected to be significant factors in determining the real farm price of beef. The positive relationship between real farm price of beef and real disposable income per capita is consistent with the widely held view that the demand for beef is an increasing function of income, or in other words, that beef is not an inferior product. Also the equation substantiates the expected inverse relationship that exists between real farm price and total liveweight of beef commercially slaughtered per capita.

Cox, et al. (9, p. 4) indicate that price level and total beef production accounted for 71 percent of the total variation in the annual farm price of beef cattle in the United States during the period from 1931 to 1950.

Both the present study and the one just cited indicate that supplies of competing meats (i.e. poultry and hogs) are not significant factors in determining the price of beef at the slaughter house level. However, this does not necessarily imply that these are not important at the retail level. It simply indicates that at the slaughter house level, slaughterers when buying slaughter beef
cattle do not consider supplies of hogs and poultry as significant factors in determining the price they are willing to pay for beef. This is logical in that different processes are needed for treating cattle and hogs, and hence there is little or no competition for plant or equipment. Both processing lines are liable to be kept running at the same time, at the end of which the processed beef can be placed in cold storage if packing-house and retail prices are not favorable. Thus it would appear that there may be a fairly indirect relationship existing between price at the retail level and that at the farm level.

Value of the estimating equation

The estimating equation can be used to estimate the real farm price of beef in any year. In Table 13, real farm prices were estimated for the past 16 years and were compared with the actual prices received by United States farmers in real terms.

There were two reasons for calculating the residuals shown in Table 13.

The first one was to obtain some indication of the reliability of the equation. It was found in fact that over the 16 year period, the average percent difference between actual and estimate price was only 1.92.\(^1\)

The second reason for finding the residuals was to determine if any autocorrelation or serial correlation existed between

\(^1\) Also see Figure 19.
Table 13. Comparison of actual and estimated real prices per 100 pounds of commercially slaughtered beef received by United States farmers, 1947 to 1962.

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual price/100 lbs. in real terms. (Dollars)</th>
<th>Estimated price/100 lbs. in real terms. (Dollars)</th>
<th>Difference (Residuals) (Dollars)</th>
<th>Percent difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>23.65</td>
<td>23.019</td>
<td>0.631</td>
<td>2.67</td>
</tr>
<tr>
<td>1948</td>
<td>26.49</td>
<td>26.740</td>
<td>-0.250</td>
<td>-0.94</td>
</tr>
<tr>
<td>1949</td>
<td>23.85</td>
<td>24.486</td>
<td>-0.636</td>
<td>-2.67</td>
</tr>
<tr>
<td>1950</td>
<td>27.80</td>
<td>27.543</td>
<td>0.257</td>
<td>0.92</td>
</tr>
<tr>
<td>1951</td>
<td>31.71</td>
<td>32.008</td>
<td>-0.298</td>
<td>-0.94</td>
</tr>
<tr>
<td>1952</td>
<td>26.27</td>
<td>25.836</td>
<td>0.434</td>
<td>1.65</td>
</tr>
<tr>
<td>1953</td>
<td>17.49</td>
<td>18.236</td>
<td>-0.746</td>
<td>-4.26</td>
</tr>
<tr>
<td>1954</td>
<td>17.09</td>
<td>16.975</td>
<td>0.115</td>
<td>0.67</td>
</tr>
<tr>
<td>1955</td>
<td>16.72</td>
<td>16.665</td>
<td>0.055</td>
<td>0.33</td>
</tr>
<tr>
<td>1956</td>
<td>15.73</td>
<td>16.134</td>
<td>-0.404</td>
<td>-2.57</td>
</tr>
<tr>
<td>1957</td>
<td>17.55</td>
<td>17.586</td>
<td>-0.036</td>
<td>-0.20</td>
</tr>
<tr>
<td>1958</td>
<td>21.75</td>
<td>20.506</td>
<td>1.244</td>
<td>5.72</td>
</tr>
<tr>
<td>1959</td>
<td>22.27</td>
<td>22.535</td>
<td>-0.265</td>
<td>-1.19</td>
</tr>
<tr>
<td>1960</td>
<td>19.79</td>
<td>19.231</td>
<td>0.559</td>
<td>2.82</td>
</tr>
<tr>
<td>1961</td>
<td>19.38</td>
<td>19.581</td>
<td>-0.201</td>
<td>-1.04</td>
</tr>
<tr>
<td>1962</td>
<td>20.21</td>
<td>20.647</td>
<td>-0.437</td>
<td>-2.16</td>
</tr>
</tbody>
</table>
Figure 19. Actual and estimated real prices per 100 pounds of commercially slaughtered beef received by United States farmers, 1947-1962.
successive residual values. The Durbin and Watson test described in the introduction to this study\(^1\) was used for this purpose. Usually the residuals are tested for negative and positive serial correlation. However, Anderson (3, p. 118) points out that often the experimenter desires a test of null hypothesis against the alternative of positive correlation. Cochrane and Orcutt (5, p. 36-38) give several reasons why positive autocorrelation is more important than negative autocorrelation. Consequently, for this test it was decided only to test for positive autocorrelation. The results of the test were:

Ho: That there is no positive serial correlation.

Critical region: \(k' = 3\) \(N = 16\)

\[
\begin{align*}
 d_L &= 0.75 & d_U &= 1.59
\end{align*}
\]

Results: \(d' = 2.453\)

Conclusion: Accept the hypothesis

The fact that no autocorrelation existed tends to enhance the value of the equation.

Estimation of annual farm price of slaughter beef in Oregon

In addition to predicting the United States farm price of slaughter beef cattle, the equation can be used for predicting Oregon prices by utilizing another regression equation, expressing the

---

\(^1\) See page 6.
regression of Oregon price on United States.

\[ \hat{Y} = 0.1593 + 0.9251 X \]

\[ (21.9351)^1 \]

\[ r = 0.9857 \]
\[ r^2 = 0.9716 \]
\[ S_b = 0.04223 \]

where:

\[ \hat{Y} = \text{average price per 100 pounds received by Oregon farmers in real terms.} \]

\[ X = \text{average price per 100 pounds received by United States farmers in real terms.} \]

The years used for this simple regression were 1947 to 1962.

In obtaining a prediction of Oregon real farm price of slaughter beef, an estimate of the United States real price was first computed using the regression equation derived in the preceding section. This estimate of United States farm price in real terms was then plugged into the simple regression equation, thereby giving an estimate of Oregon real farm price. For the years 1947 to 1962, the results shown in Table 14 were obtained.

Over the sixteen year period the average percent difference between actual and estimated price was 3.87 percent.\(^2\) The error

---

1 Significant at the one percent level.
2 Also see Figure 20.
Table 14. Comparison of actual and estimated real prices per 100 pounds of commercially slaughtered beef received by Oregon farmers, 1947 to 1962.

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual price/100 lbs. in real terms, (Dollars)</th>
<th>Estimated price/100 lbs. in real terms, (Dollars)</th>
<th>Difference (Residuals) (Dollars)</th>
<th>Percent difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>23.01</td>
<td>21.477</td>
<td>1.533</td>
<td>6.66</td>
</tr>
<tr>
<td>1948</td>
<td>24.22</td>
<td>24.923</td>
<td>-0.703</td>
<td>-2.90</td>
</tr>
<tr>
<td>1949</td>
<td>20.72</td>
<td>22.836</td>
<td>2.116</td>
<td>10.21</td>
</tr>
<tr>
<td>1950</td>
<td>26.01</td>
<td>25.667</td>
<td>0.343</td>
<td>1.32</td>
</tr>
<tr>
<td>1951</td>
<td>30.28</td>
<td>29.802</td>
<td>0.478</td>
<td>1.58</td>
</tr>
<tr>
<td>1952</td>
<td>23.24</td>
<td>24.086</td>
<td>-0.846</td>
<td>-3.64</td>
</tr>
<tr>
<td>1953</td>
<td>16.31</td>
<td>17.048</td>
<td>-0.738</td>
<td>4.52</td>
</tr>
<tr>
<td>1954</td>
<td>15.92</td>
<td>15.880</td>
<td>0.040</td>
<td>0.25</td>
</tr>
<tr>
<td>1955</td>
<td>15.22</td>
<td>15.593</td>
<td>-0.373</td>
<td>-2.45</td>
</tr>
<tr>
<td>1956</td>
<td>14.15</td>
<td>15.101</td>
<td>-0.951</td>
<td>-6.72</td>
</tr>
<tr>
<td>1957</td>
<td>17.04</td>
<td>16.446</td>
<td>0.594</td>
<td>3.48</td>
</tr>
<tr>
<td>1958</td>
<td>21.15</td>
<td>19.150</td>
<td>2.000</td>
<td>9.46</td>
</tr>
<tr>
<td>1959</td>
<td>20.79</td>
<td>21.029</td>
<td>-0.239</td>
<td>-1.15</td>
</tr>
<tr>
<td>1960</td>
<td>18.52</td>
<td>17.969</td>
<td>0.551</td>
<td>2.97</td>
</tr>
<tr>
<td>1961</td>
<td>18.95</td>
<td>18.293</td>
<td>0.657</td>
<td>3.47</td>
</tr>
<tr>
<td>1962</td>
<td>19.07</td>
<td>19.280</td>
<td>-0.210</td>
<td>-1.10</td>
</tr>
</tbody>
</table>
Figure 20. Actual and estimated real prices per 100 pounds of commercially slaughtered beef received by Oregon farmers, 1947-1962.

Price/100 lbs.
in real terms
in estimating Oregon prices is understandably somewhat higher than in estimating United States prices due to the method of computation employed. Briefly, the error was higher due to an initial error in estimating United States prices which was added to the error resulting from estimating Oregon prices from United States prices. Nevertheless this method does permit a reasonable estimate of Oregon prices to be obtained.

Finally, the Durbin and Watson test was carried out on the residuals to see if any autocorrelation existed. The one tail test was used.

Ho: That there is no positive serial correlation.

Critical region: \( k' = 1 \quad N = 16 \)

\[ d_L = 0.98 \quad d_U = 1.24 \]

Results: \( d' = 1.9618 \)

Conclusion: Accept the hypothesis.

The fact that no positive serial correlation was found helps to enhance the value of this method of calculating Oregon prices received by farmers for beef slaughter cattle.

Estimation of monthly farm price of slaughter beef in Oregon

It was also possible to estimate monthly prices of slaughter cattle by utilizing seasonal indexes and the estimates of annual price of slaughter cattle in Oregon computed in the preceding section.
The seasonal relatives calculated in Chapter 4 for slaughter cattle prices (all grades) in Oregon during the period 1951 to 1961 were multiplied by the estimates of annual farm price in Oregon, which were first expressed in monetary rather than real terms. A correlation coefficient of 0.8402\(^1\) proved to exist between the estimated and actual monthly prices of slaughter cattle in Oregon during the period 1951 to 1961.

Thus a reasonably accurate estimate of the farm price in a specified month in a particular year can be obtained.

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\(^1\) Significant at the one percent level.
CHAPTER 6

FACTORS INFLUENCING THE ANNUAL PRICE
OF FEEDERS AND STOCKERS

Theoretical development of the feeder
and stocker cattle market

Demand for a factor of production

In the analysis presented in this chapter, stocker and feeder
cattle can be considered an input or factor of production in produc-
ing the product of slaughter cattle. Therefore the demand equation
for the input of feeder and stocker cattle can be developed in a
similar fashion to the one derived for slaughter cattle in the pre-
ceding chapter.

A production function for slaughter beef would include the
following variables:

\[ O = f(Q_S, C, x_1 \ldots x_n | C_F, W, z_1 \ldots z_m)^1 \]

where:

\( O \) = output of slaughter cattle.
\( Q_S \) = numbers of head of feeders and stockers.
\( C \) = size of grain corn crop.
\( C_F \) = numbers of cattle on feed.

---

1 At any one point in time numbers of cattle on feed and average
weight of feeder and stocker can be considered fixed.
$W = \text{average weight per head of stocker and feeder.}$

$x_1 \ldots x_n = \text{other variable inputs.}$

$z_1 \ldots z_m = \text{other fixed inputs.}$

For the purposes of this analysis, the production function is assumed to be non-linear.

The output of the productive process consists of slaughter cattle.

\begin{equation}
(2) \quad \text{Therefore } O = Q_F
\end{equation}

where:

$Q_F = \text{numbers of slaughter cattle produced.}$

Total cost can now be found by multiplying the quantities used of the inputs by their respective prices per unit.

\begin{equation}
(3) \quad \text{T.C.} = P_S Q_S + P_C C + P_{x_1} X_1 + \ldots + P_{x_n} X_n + A
\end{equation}

where:

$P_S = \text{price per head of feeder and stocker.}$

$P_C = \text{price of corn.}$

$P_{x_1}, \ldots, P_{x_n} = \text{price per unit of other variable inputs.}$

$A = \text{fixed costs.}$

On turning to the revenue side, the producer when deciding the quantities of various inputs to use will not know what the price of slaughter cattle will be when the fattening period is finished. However, although there may be a gap of up to three or five months
between the time of decision of the quantities of inputs to use and the time the finished animal is taken to the market, the producer will formulate an idea of the price he can expect to get for the product. Thus expected total revenue can be expressed as follows:

\[(4) \quad T.R.^* = P_F^* Q_F \]

where:

\[P_F^* = \text{expected price of slaughter cattle.} \]

An expected profit equation for the producer can now be derived by subtracting total costs from expected total returns.

\[\prod^* = T.R.^* - T.C. \]

\[= P_F^* Q_F - P_S Q_S - P_C C - P_{x_1} X_1 \ldots - P_{x_n} X_n - A \]

Taking the partial derivative of expected profit with respect to input of feeders and stockers gives rise to the following:

\[(5) \quad \frac{\partial \prod^*}{\partial Q_S} = \left( \frac{\partial P_F^*}{\partial Q_S} \right) P_F^* - P_S \]

To find the optimum economic point, equation (5) is set equal to zero.

\[(6) \quad \text{Therefore} \quad \left( \frac{\partial P_F^*}{\partial Q_S} \right) P_F^* = P_S \]

In equation (2) output was found to consist of slaughter cattle only.

\[\text{Therefore} \quad \left( \frac{\partial Q}{\partial Q_S} \right) P_F^* = P_S \]
As it was assumed that the production function was non-linear, the partial derivative of output of slaughter beef with respect to input of feeders and stockers will include all the inputs specified in the production function. Therefore, the demand equation for feeders and stockers can now be written as:

\[ P_S = h(Q^D_S, C, C_F, W, P_F^*) \] (7)

If equation (7) is to be expressed in monetary terms, then an additional variable, namely general price level (G) should be included.

\[ P_S = h(Q^D_S, C, C_F, W, G, P_F^*) \] (8)

The supply of stocker and feeder cattle.

Once again, as in the last chapter, the supply equation was considered pre-determined in that farmers base their decisions on

---

1 Numbers of cattle on feed and average weight per stocker and feeder will be constant at any one point in time but will vary from period to period. If for example the production function was:

\[ O = aQSC + bQSC_F + dQS_W \]

then:

\[ \frac{\partial O}{\partial Q_S} = aC + bC_F + dW \]

\[ = g(C, C_F, W) \]

2 The preceding analysis assumed that prices were expressed in real terms.

3 The rationale behind the inclusion of the variables is discussed in a subsequent section. See pages 105-108.
numbers to supply, on factors other than price of feeders and stockers. The following factors were considered to influence the supply of feeders and stockers.

\( Q^S \) = numbers of feeders and stockers supplied.

**Equilibrium Point**

The supply and demand schedules intersect to determine the equilibrium price for feeders and stockers.

**Rationale behind the inclusion of the variables in the diagram**

The reasons for including the various variables are discussed below.

Six factors were considered of importance on the demand side of the market.

1. Average weight of stockers and feeders. This variable will bear a direct relationship with the price per head of feeders
Figure 21. Diagram showing the factors considered important in determining the annual price of feeders and stockers.

- Change in numbers of cattle sold off the range: \((N_{Rt} - N_{Rt-1})\)
- Change from current and past years' price of slaughter cattle: \((P_{Ft} + P_{Ft} - P_{Ft-1})\)
- Expected price of slaughter beef: \(P_{Ft+1}\)
- Size of corn crop: \(C_t\)
- Price level: \(G_t\)
- Demand for feeders and stockers in numbers head: \(Q^D_{St}\)
- Numbers of cattle on feed: \(C_{Ft}\)
- Average weight of stockers and feeders: \(W_t\)
- Supply of feeders and stockers: \(Q^S_{St}\)
- Price per head of feeders and stockers: \(P_{St}\)

- Numbers of breeding cows on range the previous year: \(B_{t-1}\)
- Numbers of cattle on range Jan. 1st: \(K_{t-1}\)
- Range conditions in 17 Western states: \(R_t\)
- Conditions of cattle on range: \(L_t\)
and stockers. Obviously, the heavier the animal is, the higher will be the price that the purchaser will be prepared to pay. Average weight is therefore a significant factor in determining the price per head of stockers and feeders.

2. Expected price of slaughter beef. For reasons explained earlier, price per head that producers will be prepared to pay for stockers and feeders will be influenced to a considerable extent by the expected price of slaughter beef, as this will help determine the revenue and profit they can expect from the fattening process. Obviously, a direct relationship can be expected to exist between the price of the input, feeders and stockers, and the expected price of the product, slaughter cattle.

It is likely that the producers will base their estimations of price of slaughter cattle on some relationship between the current price and the change from the preceding year's price. Numbers of cattle sold off the range as grass fattened animals could also have some influence on the decisions as to the revenue producers can expect to get from slaughter cattle fattened in the feedlots. If the numbers of cattle sold off the range are increasing, producers may feel that as a result of the increase in supplies of slaughter cattle from other sources, they can expect a somewhat lower price for those fattened in feedlots.

---

1 See page 102.
Therefore \[ P_{Ft+1}^* = \ell(P_{Ft}, P_{Ft-1}, N_{Rt}, N_{Rt-1}) \]
or
\[ P_{Ft+1}^* = P_{Ft} + \lambda(P_{Ft} - P_{Ft-1}) + \rho(N_{Rt} - N_{Rt-1}) \]
where:

\[ \lambda \text{ and } \rho \text{ are constants.} \]

3. Size of corn crop. The size of the corn crop will determine the numbers of feeders that can be fed and will therefore affect the demand and hence price for feeders and stockers. Also a larger corn crop implies lower feed costs and thus increased feeding margins. Consequently, the size of corn crop and price per head of feeders and stockers can be expected to exhibit a direct relationship with each other.

4. Price level. The reasoning behind the inclusion of this variable is the same as that used for its presence in the price equation of slaughter cattle. Prices of feeders and stockers will tend to move in the same direction as changes in the price level.

5. Numbers of cattle on feed. In this case, it can be expected that the higher the numbers on feed, the lower will be the demand for and hence the price of feeders and stockers.

6. Numbers of feeders and stockers demanded. It can be expected that this variable and the price per head of feeders and stockers will obey the law of demand, which states that an inverse relationship exists between price and quantity demanded of a good.
Supply of feeders and stockers was considered to be determined by four main factors.

1. Numbers of breeding cows on range the previous year. This variable could be expected to have a direct relationship with the supply of feeders and stockers, as the numbers of breeding cows the previous year will influence the numbers of calves born, which will determine the number of feeders and stockers available in the current year.

2. Numbers of cattle on range January the first. Once again, a direct relationship exists as the numbers of cattle on range at the beginning of the current year will influence the number of feeders and stockers available in the current year.

3. Range conditions in the 17 Western States. When range conditions are poor, ranchers tend to reduce their breeding herds and numbers of young stock (feeders) in order to avoid the higher cost entailed in using harvested feeds. Good range conditions encourage expansion in breeding herds and subsequently, increased supplies of feeders in future -- not current-- years. Thus a direct relationship can be expected to exist between range conditions and the supplies of feeders and stockers.

4. Condition of cattle on range. At first glance, it would appear that this variable is synonymous with range conditions in the 17 Western states. However, condition of cattle on range is a function of both the aforementioned variable and the numbers of cattle on range on January the first. It is quite conceivable that in
In this model, it was considered that the price of feeders and stockers would not affect the numbers of head of feeders and stockers supplied (Qt) in the same year. This seems reasonable enough when consideration is directed towards the fact that there is a comparatively long production process as well as a lack of flexibility in the way of alternative outlets for feeders and stockers.

All of these variables affect the quantity supplied in the current year but are not affected by it. Therefore, supply can be considered exogenous.

The Model

It is possible to express the variables in Figure 21 in the form of a model.

Equation 1. Demand for feeders and stockers.

\[ P_{St} = h(P_{Ft+1}^*, C_t, G_t, N_{CFt}, Q_{St}^D, W_t) \]

Equation 2. Supply of feeders and stockers.

\[ Q_{St} = k(B_{t-1}, K_t, R_t, L_t) \]

Equation 3.

\[ P_{Ft+1}^* = P_{Ft} + \lambda(P_{Ft} - P_{Ft-1}) + \rho(N_{Rt} - N_{Rt-1}) \]

1 In this model, it was considered that the price of feeders and stockers \( (P_{St}) \) would not affect the numbers of head of feeders and stockers supplied \( (Q_{St}) \) in the same year. This seems reasonable enough when consideration is directed towards the fact that there is a comparatively long production process as well as a lack of flexibility in the way of alternative outlets for feeders and stockers.
Identity.

\[ Q_{St}^D = Q_S = Q_{St} \]

All the variables in equations one and two are exogenous, except the price of feeders and stockers in equation one and the supply of feeders and stockers in equation two. Thus the method of least squares can be used in estimating the two variables specified in the last sentence.

By utilizing the identity, an estimate of equilibrium quantity can be derived from equation two and plugged into equation one, or the actual pre-determined equilibrium quantity can be used instead, in equation one. The latter value of the variable was used, thus avoiding a compounding of errors mentioned at a similar point in the last chapter.

Therefore the following price equation is derived:

\[ P_{St} = (Q_{St}, C_t, G_t, N_{CFt}, W, P_{Ft+1}) \]

**Empirical results**

The estimating equation for price of stockers and feeders

The price equation derived in the previous section was used for estimation purposes after being slightly modified.

**Oregon and United States prices**

An explicitly stated variable showing the price of feeders and stockers on a United States basis was found to be unavailable.
However, by some manipulation it was possible to derive prices from available statistics. These derived prices were compared with Kansas City and Ontario (Oregon) prices, with the results shown in Figure 22.

Figure 22. Correlation of annual prices between various feeder and stocker markets, 1947 to 1962.

- Annual U.S. feeding and breeding cattle prices (a derived statistic)
  - $r = 0.9877$
  - $r = 0.9652$ (1952 to 1962)

- (a) Annual feeder and stocker steer prices (all weights)
  - Annual Ontario feeder and stocker good and choice steers (less than 700 pounds)
  - $r = 0.9472$

- (b) Annual feeder and stocker steer prices (501 to 700 pounds)

The correlations were determined using data deflated by the consumer price index (1957 to 1959 = 100). Due to the limited data available, especially from Oregon, it was not possible to use identical classes at the three markets studied.

---

1 In Agricultural Statistics (31, p. 320) numbers of cattle shipped in for feeding and breeding were divided into the cost of cattle shipped in for feeding and breeding, thereby giving an idea of average cost per head.
However, from the above results it would appear that the prices derived for the United States do reflect the true prices in the nation as they are very highly correlated with Kansas City prices, which is the largest single market for stockers and feeders in the country. At the same time a high correlation proved to exist between United States and Ontario (Oregon) prices. Thus due to Oregon being an insignificant contributor to the total numbers of feeders and stockers in the nation, it was felt that a price equation derived for the United States as a whole could give a fairly accurate estimate of Oregon prices, which are so dependent upon the national prices.

Time period selected

A time period similar to that used in estimating slaughter beef prices was adopted. The 16 year period 1947 to 1962 was selected for exactly the same reasons as stated in the preceding chapter; namely that abnormal conditions such as war and rationing existed prior to 1947, therefore upsetting the consumption patterns etc., that usually prevail in time of peace.

Modifications to the price equation

Due to unavailability of data it was not possible to include the numbers of cattle sold off the range. Therefore the expected farm price of slaughter beef was modified as follows:

\[ P_{Ft+1}^* = P_{Ft} + \lambda (P_{Ft} - P_{Ft-1}) + P_{Ft} (1 + \lambda) - \lambda P_{Ft-1} \]
The estimating price equation for feeders and stockers was modified by making the price level implicit, thereby reducing the number of explicit variables and increasing the residual degrees of freedom. The data was deflated using the consumer price index (1957 to 1959 = 100).

The model therefore became:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_7 X_7$$

where:

- $Y$ = price per head of feeding and breeding cattle in the United States, expressed in real terms.
- $X_1$ = numbers of head of stockers and breeding cattle shipped in 1,000 head.
- $X_2$ = size of grain corn crop in 1,000 bushels
- $X_3$ = numbers of cattle on feed January the first in 1,000 head.
- $X_4$ = average weight in pounds per head of feeder steers of all weights (calculated on a basis of weighted average weight in the ten main markets of the United States).
- $X_7 = P^*_{Ft+1}$ = expected farm price of slaughter beef per 100 pounds to be received by United States farmers and expressed in real terms.

Therefore

$$Y = \beta_0 + \beta_1 X_1 - \beta_4 X_4 + \beta_7 (1 + \lambda) P_{Ft} - \beta_7 \lambda P_{Ft-1}$$

Let:

$$\beta_7 (1 + \lambda) = \beta_5$$

$$- \beta_7 \lambda = \beta_6$$
Thus the final price estimating equation for stockers and feeders was derived:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 \]

where:

- \( X_1 \) to \( X_4 \) = similar to those specified on the previous page.
- \( X_5 \) = price of slaughter beef per 100 pounds received by United States farmers in the current year and expressed in real terms.
- \( X_6 \) = price of slaughter beef per 100 pounds received by United States farmers in the preceding year and expressed in real terms.

Further discussion on the rationale behind the inclusion of these variables is unnecessary, this having been covered in a previous section. According to the argument presented there, it was expected that the signs on all the parameters would be positive,with the exception of numbers of head shipped in for feeding and breeding and the numbers of cattle on feed.

A stepwise regression was employed on the price equation and gave rise to the results discussed in the next section.

Results of the regression analysis

The decision concerning the estimating equation to accept in stepwise regression analysis is determined by the specifications

---

1 See pages 105 to 108.
2 \( \beta_5 \) and \( \beta_6 \) were not considered as they were simply sub-sections of the expected price of slaughter beef.
mentioned in the introduction to this study. 1

Two steps in this particular stepwise regression were
considered to be of some significance. 2

\[ \hat{Y} = -19.93042 + 0.0000055758X_2 + 9.22947X_5 - 1.75242X_6 \]
\[ (2.57842)^3 \quad (29.40525)^3 \quad (5.63364)^3 \]

R = 0.9955 4
R^2 = 0.99096 5

\[ S_{yx} = 3.92428 \]

\[ \hat{Y} = -132.49251 + 0.0000063075X_2 + 0.17069X_4 + 8.39662X_5 - 1.54999X_6 \]
\[ (3.01575)^3 \quad (1.57827)^3 \quad (13.87748)^3 \]
\[ (-4.84093)^3 \]

R = 0.9963
R^2 = 0.99263

\[ S_{yx} = 3.70109 \]

where:

\[ \hat{Y} \quad \text{price per head of feeding and breeding cattle in the} \]
\[ \text{United States, expressed in real terms.} \]

---

1 See page 2 .
2 For full results see the Appendix page 137.
3 The T-ratios in parenthesis are all significant at the one percent level except for X_4 .
4 Significant at the one percent level.
5 An R^2 of 0.99096 means that the three independent variables explain 99.096 percent of the variation in the prices of feeding and breeding cattle.
\( X_2 \) = size of corn grain crop in 1,000 bushel units.

\( X_4 \) = average weight in pounds per head of feeder steers of all weights (calculated on the basis of weighted average weight in the ten main markets of the United States).

\( X_5 \) = price of slaughter beef per 100 pounds received by United States farmers in the current year and expressed in real terms.

\( X_6 \) = price of slaughter beef per 100 pounds received by United States farmers in the preceding year and expressed in real terms.

A test (28, p. 454) given by Snedecor was used to determine whether the coefficient of multiple determination \( R^2 \) increased significantly in moving from regression equation (1) to regression equation (2). The results were as follows:

\[
\text{Ho: } R^2(1) = R^2(2)
\]

Critical region: \( F_{11} > 4.8443 \) at five percent level of significance.

Results:

Analysis of variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sums of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviations from regression (1)</td>
<td>12</td>
<td>184.8000</td>
<td>15.4000</td>
</tr>
<tr>
<td>Deviation from regression (2)</td>
<td>11</td>
<td>150.6791</td>
<td>13.6981</td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>34.1209</td>
<td></td>
</tr>
</tbody>
</table>
$$F = \frac{34.1209}{13.6981} = 2.4909$$

Conclusion: Accept the hypothesis.

Therefore the coefficient of multiple determination is not increased significantly in moving from regression equation (1) to regression equation (2).

However in spite of the non-significance it was decided to accept regression equation (2) in preference to (1) as the standard error of estimate of $Y$ on $X$ was reduced from 3.92428 in (1) to 3.70109 in (2), thereby giving rise to a closer fit.

Therefore further analysis and comments were confined to estimating equation (2) with four independent variables.

**Interpretation of regression equation (2)**

The relationships shown in the equation can be expressed as follows:

(a) Price of feeders and stockers in real terms increases six cents per head, when the size of the grain corn crop increases 1,000,000 bushels, all other factors being held constant.

(b) Price of feeders and stockers in real terms increases 17 cents per head, when the average weight per head increases by one pound, all other things being held constant.

(c) The current and lagged prices of slaughter beef were used in deriving the expected price of beef equation in real terms.
Substituting the value of $\beta_7$ into (ii)

\[ \beta_7 = \beta_5 + \beta_6 = 8.39662 + (-1.54999) = 6.84663 \]

Therefore

\[
\begin{align*}
P_{Ft+1}^* &= P_{Ft} + 0.022639 (P_{Ft} - P_{Ft-1})
\end{align*}
\]

where:

- $P_{Ft+1}^*$ is expected price in dollars per 100 pounds expressed in real terms to be received by United States farmers for slaughter beef.
- $P_{Ft}$ is price in dollars per 100 pounds expressed in real terms, received by United States farmers for slaughter beef, in the current year.
- $P_{Ft-1}$ is price in dollars per 100 pounds expressed in real terms, received by United States farmers for slaughter beef, in the previous year.

The positive sign resulting on the constant $(\lambda)$ on the expected price equation indicates that if the price this year is higher than last year, then producers expect higher prices next year. Conversely, if the price this year is lower than last year, then producers expect a lower price next year.

The positive sign on the $\beta_7$ value indicates that the price of feeders and stockers in real terms increases 6.8 dollars per head,

1 For the origin of these equations see page 114.
when the expected price in real terms increases by one dollar per 100 pounds.

Therefore, expected prices of slaughter beef appear to be a very important factor in determining the price of feeders and stockers which is simply an input for the output of slaughter cattle. The higher the product price is, the more the producer will be willing to pay for the inputs, for example stockers and feeders. The grain corn crop\(^1\) was also understandably an important factor in determining the price of feeders and stockers, as corn constitutes the main food supply in feedlots. The average weight per head was also found to be one of the more important variables in determining the price per head of feeder and stocker.

Numbers of cattle on feed and especially numbers of feeders and stockers shipped were not found to be significant factors in influencing the price of feeders and stockers. It would usually be expected that the numbers of feeders and stockers shipped would be an important variable, but the price per head is apparently determined by other more important factors, especially the expected price of the product, slaughter beef.

**Assessment of the value of the regression equation**

To assess the value of the price equation for feeders and

---

\(^1\) Cox, et al. (6, p. 28) found that price level and size of the corn crop accounted for 70 percent of the variation in annual price of feeders and stockers at Kansas City.
stockers, the mean percentage difference was calculated in addition to the percentage differences for the individual years and the Durbin and Watson test was carried out.

The results in Table 15 show that over the 16 year period, the average percent difference between actual and estimated prices was only 1.54.¹

A two tail test using the Durbin and Watson method was used in investigating if there was any serial correlation. The results were:

Ho: That there is no negative or positive serial correlation.

Critical regions: \( K' = 4 \quad N = 16 \)

\[
d_L = 0.64 \quad d_U = 1.80
\]

Results: \( d' = 1.99306 \)

\( 4-d' = 2.00694 \)

Conclusion: Accept the hypothesis.

The fact that no autocorrelation existed tends to enhance the value of the equation.

Estimation of annual price of feeders and stockers in Oregon

An estimate of annual Ontario (Oregon) feeder and stocker good and choice steer prices (less than 700 pounds) was obtained by

¹ See also Figure 23.
Table 15. Comparison of actual and estimated real prices per head of feeder and breeding cattle in the United States, 1947 to 1962.

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual price per head in real terms (Dollars)</th>
<th>Estimated price per head in real terms (Dollars)</th>
<th>Difference (Residuals) (Dollars)</th>
<th>Percent difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>168.30</td>
<td>173.33</td>
<td>-5.03</td>
<td>-2.99</td>
</tr>
<tr>
<td>1948</td>
<td>201.88</td>
<td>204.03</td>
<td>-2.15</td>
<td>-1.06</td>
</tr>
<tr>
<td>1949</td>
<td>173.48</td>
<td>173.99</td>
<td>-0.51</td>
<td>-0.29</td>
</tr>
<tr>
<td>1950</td>
<td>216.99</td>
<td>209.76</td>
<td>7.23</td>
<td>3.33</td>
</tr>
<tr>
<td>1951</td>
<td>237.93</td>
<td>237.15</td>
<td>0.78</td>
<td>0.33</td>
</tr>
<tr>
<td>1952</td>
<td>178.39</td>
<td>181.15</td>
<td>-2.76</td>
<td>-1.55</td>
</tr>
<tr>
<td>1953</td>
<td>116.72</td>
<td>112.16</td>
<td>4.56</td>
<td>3.91</td>
</tr>
<tr>
<td>1954</td>
<td>118.67</td>
<td>120.80</td>
<td>-2.13</td>
<td>-1.79</td>
</tr>
<tr>
<td>1955</td>
<td>120.31</td>
<td>120.72</td>
<td>-0.41</td>
<td>-0.34</td>
</tr>
<tr>
<td>1956</td>
<td>111.11</td>
<td>112.72</td>
<td>-1.61</td>
<td>-1.45</td>
</tr>
<tr>
<td>1957</td>
<td>135.21</td>
<td>131.06</td>
<td>4.15</td>
<td>3.07</td>
</tr>
<tr>
<td>1958</td>
<td>170.05</td>
<td>169.39</td>
<td>0.66</td>
<td>0.39</td>
</tr>
<tr>
<td>1959</td>
<td>165.55</td>
<td>168.32</td>
<td>-2.77</td>
<td>-1.67</td>
</tr>
<tr>
<td>1960</td>
<td>145.11</td>
<td>145.34</td>
<td>-0.23</td>
<td>-0.16</td>
</tr>
<tr>
<td>1961</td>
<td>146.39</td>
<td>144.47</td>
<td>1.92</td>
<td>1.31</td>
</tr>
<tr>
<td>1962</td>
<td>150.21</td>
<td>151.85</td>
<td>-1.64</td>
<td>-1.09</td>
</tr>
</tbody>
</table>
Figure 23. Actual and estimated real prices per head of feeder and stocker cattle in the United States, 1947-1962.
estimating the United States price per head for feeders and stockers, reducing it to price per 100 pounds, and then plugging that estimate into a simple regression equation expressing the relationship between Ontario feeder and stocker good and choice steer prices and United States feeder and stocker prices. The simple regression equation used was:

\[ \hat{Y} = -2.0583 + 1.2566 X \]

\( (11.3309)^1 \)

where:

\( \hat{Y} \) = price per 100 pounds of feeder and stocker good and choice steers at Ontario (Oregon) in real terms.

\( X \) = price per 100 pounds of feeder and stocker cattle in the United States expressed in real terms.

\( r \) = 0.9652 \(^2\)

\( r^2 \) = 0.9316

\( S_b \) = 0.1109

The results in Table 16 show that over the 11 year period the average percent difference between actual and estimated prices per 100 pounds feeder and stocker good and choice steers at Ontario (Oregon) was only 2.65 percent. \(^3\)

The error in estimating United States price is added to the error in estimating Ontario prices from

---

1. The t-value in parenthesis is significant at the one percent level.
2. Significant at the one percent level.
3. See also Figure 24.
Table 16. Comparison of actual and estimated real prices per 100 pounds of feeders and stockers, choice and good steers (under 700 pounds) at Ontario (Oregon), 1947 to 1962.

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual price/100 pounds in real terms. (Dollars)</th>
<th>Estimated price/100 pounds in real terms. (Dollars)</th>
<th>Difference (Residuals) (Dollars)</th>
<th>Percent difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>------ 1</td>
<td>27.21</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1948</td>
<td>------ 1</td>
<td>31.63</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1949</td>
<td>------ 1</td>
<td>26.93</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1950</td>
<td>------ 1</td>
<td>32.99</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1951</td>
<td>------ 1</td>
<td>37.10</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1952</td>
<td>30.95</td>
<td>29.42</td>
<td>1.53</td>
<td>4.94</td>
</tr>
<tr>
<td>1953</td>
<td>19.22</td>
<td>17.93</td>
<td>1.29</td>
<td>6.71</td>
</tr>
<tr>
<td>1954</td>
<td>19.85</td>
<td>19.57</td>
<td>0.28</td>
<td>1.41</td>
</tr>
<tr>
<td>1955</td>
<td>19.50</td>
<td>19.30</td>
<td>0.20</td>
<td>1.02</td>
</tr>
<tr>
<td>1956</td>
<td>17.94</td>
<td>18.15</td>
<td>-0.21</td>
<td>-1.17</td>
</tr>
<tr>
<td>1957</td>
<td>20.39</td>
<td>21.10</td>
<td>-0.71</td>
<td>-3.48</td>
</tr>
<tr>
<td>1958</td>
<td>25.72</td>
<td>26.94</td>
<td>-1.22</td>
<td>-4.74</td>
</tr>
<tr>
<td>1959</td>
<td>26.72</td>
<td>27.19</td>
<td>-0.47</td>
<td>-1.76</td>
</tr>
<tr>
<td>1960</td>
<td>23.71</td>
<td>23.59</td>
<td>0.12</td>
<td>0.51</td>
</tr>
<tr>
<td>1961</td>
<td>23.22</td>
<td>23.32</td>
<td>-0.10</td>
<td>-0.43</td>
</tr>
<tr>
<td>1962</td>
<td>23.99</td>
<td>24.71</td>
<td>-0.72</td>
<td>-3.00</td>
</tr>
</tbody>
</table>

1 The figures for these years were not available at Ontario (Oregon).
Figure 24. Actual and estimated prices per 100 pounds in real terms of feeder and stocker good and choice steers at Ontario (Oregon), 1947-1962.

Real prices/100 lbs. of feeder and stocker

- Actual price
- Estimated price
estimates of United States prices. Nevertheless a close fit is achieved, thus providing a satisfactory means of estimating Ontario prices. ¹

¹ Unfortunately it was not possible to use the Durbin and Watson test for testing for serial correlation, as critical regions are not specified for samples of less than 15 observations (N).
CHAPTER 7

SUMMARY AND CONCLUSIONS

In this study considerable emphasis was placed on the utilization of statistical techniques. Throughout the analysis the assumptions underlying statistical analysis were constantly borne in mind. Where deemed necessary, tests for such assumptions as autocorrelation were utilized. Limitations of data proved to be a handicap at times but in most cases the resulting hurdle was circumnavigated without too much difficulty.

The beef cattle industry in Oregon although very insignificant relative to the national aggregate has been holding its own, and in fact compared with the dairy industry inside the state itself has been progressing significantly.

Beef cattle cycles when viewed in terms of numbers of beef cattle on farms and prices received by United States farmers were found to be an average duration of 11 years with a range of nine to 14 years in length. The very high correlation coefficients found to exist between the United States and Oregon in terms of prices received by farmers and numbers of beef cattle on farms permitted the conclusion to be reached that the beef cycles in Oregon are virtually identical to those on the national scale.

In terms of seasonal variation of numbers slaughtered, Oregon's peak slaughter month has receded to August compared with
October for the nation as a whole. Seasonal prices received by farmers in the state and nation were very similar, maximum prices occurring in May and minimum prices in November. It was found, however, that in Oregon seasonal variations in production did not show a counter seasonal pattern to prices. Numbers of head of feeders and stockers marketed at Kansas City showed a very pronounced seasonal pattern with a peak in October and a trough in June. This was in contrast to the insignificant seasonal variation found in prices. Unlike the steady demand usually considered to exist for slaughter cattle throughout any one year, different intensities of demand are found for feeders and stockers depending on the season.

In investigating the factors important in determining the farm price of slaughter cattle, it was found necessary to differentiate three marketing levels. As a result the demand for beef at the slaughter house level could be considered to be a derived demand for beef at the retail level. Consequently, the factors important in determining beef prices at the slaughter house need not necessarily be among the most significant variables in beef prices at the retail level. In fact at the slaughter house level disposable income per capita, total liveweight of beef commercially slaughtered per capita, and the by-product allowance in real terms were found to be significant factors in determining annual prices for beef to be received by
United States farmers, in real terms.\textsuperscript{1}

The price per head in real terms for feeders and stockers in the United States was found to be determined largely by three variables which were size of the corn grain crop, average weight per head of feeder steers, and expected price \textsuperscript{2} in real terms, of slaughter beef.\textsuperscript{3}

Due to the high correlation found to exist between Oregon and the United States as far as prices of slaughter, and feeder and stocker cattle are concerned, it was possible to obtain estimates of prices in Oregon from the prices calculated for the United States as a whole.

If a suitable basis could be found for estimating future values for the exogenous variables in the two price equations, then the forecasts could be used as predetermined variables for estimating the future prices of slaughter, and feeder and stocker cattle. The process could be repeated indefinitely as long as one is willing to assume future values for the exogenous variables.\textsuperscript{4} However, the process of choosing values for the exogenous variables and

\textsuperscript{1} It should be noted that two implicit variables, namely population and general price level, are present in the model, in addition to the three variables explicitly mentioned.

\textsuperscript{2} The value for expected price was determined by the real price of slaughter beef in the current year plus a constant times the change in real price of slaughter beef from the preceding year.

\textsuperscript{3} The general price level was included as an implicit variable.

\textsuperscript{4} Future values could be obtained by using trend estimates derived from time series data of the relevant variables.
utilizing the price equations for predictive purposes was not con-
sidered of relevance to the present study, which was simply con-
cerned with analyzing factors important in determining prices of
slaughter, and feeder and stocker cattle. Nevertheless, it would
appear that as a result of the high coefficients of multiple deter-
mination and serial independence in the two price equations, that
these equations could be used with some success as predictive tools.

In general it seems reasonable to conclude that the results
of this study have indicated that an investigation of prices and
trends in the United States can serve as rough guide as to what is
happening inside the state of Oregon.


23. Purcell, J.C. Analysis of hog prices on Georgia markets. Athens, 1959. (Georgia Agriculture Experiment Station. 34p. Bulletin N.S. 62)


Table 17 - Seasonal relatives for cattle in Oregon and the United States

<table>
<thead>
<tr>
<th>Month</th>
<th>Slaughter cattle</th>
<th></th>
<th></th>
<th></th>
<th>Feeder and stocker steers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price per 100 pounds received by farmers</td>
<td>Number of head</td>
<td>Price per head</td>
<td>Number of head</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>98.2</td>
<td>101.2</td>
<td>99.5</td>
<td>98.7</td>
<td>104.9</td>
<td>98.3</td>
<td>73.0</td>
</tr>
<tr>
<td>February</td>
<td>100.2</td>
<td>101.4</td>
<td>97.0</td>
<td>97.5</td>
<td>85.6</td>
<td>102.0</td>
<td>72.4</td>
</tr>
<tr>
<td>March</td>
<td>101.8</td>
<td>107.2</td>
<td>98.4</td>
<td>100.2</td>
<td>98.8</td>
<td>106.2</td>
<td>82.4</td>
</tr>
<tr>
<td>April</td>
<td>104.3</td>
<td>106.1</td>
<td>100.3</td>
<td>101.8</td>
<td>94.2</td>
<td>107.2</td>
<td>99.0</td>
</tr>
<tr>
<td>May</td>
<td>105.5</td>
<td>108.5</td>
<td>99.5</td>
<td>104.0</td>
<td>96.7</td>
<td>107.6</td>
<td>63.7</td>
</tr>
<tr>
<td>June</td>
<td>103.0</td>
<td>102.0</td>
<td>100.6</td>
<td>101.9</td>
<td>102.4</td>
<td>98.5</td>
<td>43.8</td>
</tr>
<tr>
<td>July</td>
<td>102.9</td>
<td>98.1</td>
<td>102.6</td>
<td>103.9</td>
<td>106.2</td>
<td>95.9</td>
<td>70.8</td>
</tr>
<tr>
<td>August</td>
<td>99.5</td>
<td>96.4</td>
<td>101.9</td>
<td>101.7</td>
<td>111.1</td>
<td>96.7</td>
<td>130.5</td>
</tr>
<tr>
<td>September</td>
<td>99.2</td>
<td>98.9</td>
<td>101.6</td>
<td>101.4</td>
<td>106.3</td>
<td>95.8</td>
<td>170.7</td>
</tr>
<tr>
<td>October</td>
<td>97.2</td>
<td>95.1</td>
<td>102.2</td>
<td>99.4</td>
<td>106.8</td>
<td>97.1</td>
<td>190.7</td>
</tr>
<tr>
<td>November</td>
<td>93.6</td>
<td>91.3</td>
<td>99.1</td>
<td>94.4</td>
<td>95.6</td>
<td>97.5</td>
<td>124.6</td>
</tr>
<tr>
<td>December</td>
<td>94.5</td>
<td>93.9</td>
<td>97.5</td>
<td>94.0</td>
<td>91.1</td>
<td>97.3</td>
<td>78.4</td>
</tr>
</tbody>
</table>
Detailed results of stepwise regression for farm price of slaughter cattle in the United States

Step 1.
\[ \hat{\beta}_0 = 58.49651 \]
\[ \hat{\beta}_3 = -2.27944 \]
\[ S_{yx} = 1.50149 \]
\[ R^2 = 0.90070 \]  

Step 2.
\[ \hat{\beta}_0 = 41.70373 \]
\[ \hat{\beta}_1 = 0.96144 \]
\[ \hat{\beta}_2 = -0.19201 \]
\[ S_{yx} = 1.18805 \]
\[ R^2 = 0.94227 \]  

Step 3.
\[ \hat{\beta}_0 = 19.41227 \]
\[ \hat{\beta}_1 = 1.66456 \]
\[ \hat{\beta}_2 = 0.01085 \]
\[ \hat{\beta}_3 = -0.19481 \]
\[ S_{yx} = 0.58486 \]
\[ R^2 = 0.98708 \]  

Step 4.
\[ \hat{\beta}_0 = 24.84983 \]
\[ \hat{\beta}_1 = 1.67854 \]
\[ \hat{\beta}_2 = 0.00619 \]
\[ \hat{\beta}_3 = -0.18589 \]
\[ \hat{\beta}_4 = 0.06541 \]
\[ S_{yx} = 0.58174 \]
\[ R^2 = 0.98828 \]  

Step 5.
\[ \hat{\beta}_0 = 24.99849 \]
\[ \hat{\beta}_1 = 1.67781 \]
\[ \hat{\beta}_2 = 0.00570 \]
\[ \hat{\beta}_3 = -0.18077 \]
\[ \hat{\beta}_4 = 0.06013 \]

1 See page 87 for explanation of the variables included.
2 Figures in parentheses are T-values.
Detailed results of stepwise regression for price per head of feeder and breeding cattle in the United States.

Step 1.
\[ \hat{\beta}_o = -11.24569 \]
\[ \hat{\beta}_s = 7.86838 \quad (18.80186) \]
\[ S_{yx} = 7.46113 \]
\[ R^2 = 0.96196 \]

Step 2.
\[ \hat{\beta}_o = 0.28064 \]
\[ \hat{\beta}_s = 9.10214 \quad (24.51810) \]
\[ \hat{\beta}_6 = -1.75847 \quad (-4.72010) \]
\[ S_{yx} = 4.70011 \]
\[ R^2 = 0.98596 \]

Step 3.
\[ \hat{\beta}_o = -19.93042 \]
\[ \hat{\beta}_s = -0.000055758 \quad (2.57842) \]
\[ \hat{\beta}_s = 9.22947 \quad (29.40525) \]
\[ \hat{\beta}_6 = -1.75242 \quad (-5.63364) \]

See page 115 for explanation of the variables included.
Step 4.

\[ \hat{a} = -132.49251 \]
\[ \hat{b} = 0.0000063075 \quad (3.01575) \]
\[ \hat{c} = 0.17069 \quad (1.57827) \]
\[ \hat{d} = 8.39662 \quad (13.87748) \]
\[ \hat{e} = -1.54999 \quad (-4.84093) \]
\[ S_{yx} = 3.70109 \]
\[ R^2 = 0.99263 \]

Step 5.

\[ \hat{a} = -154.95480 \]
\[ \hat{b} = 0.0000052780 \quad (1.53664) \]
\[ \hat{c} = 0.00073 \quad (0.38754) \]
\[ \hat{d} = 0.20097 \quad (1.46645) \]
\[ \hat{e} = 8.32901 \quad (12.74353) \]
\[ \hat{f} = -1.50478 \quad (-4.26119) \]
\[ S_{yx} = 3.85291 \]
\[ R^2 = 0.99274 \]

Step 6.

\[ \hat{a} = -159.66885 \]
\[ \hat{b} = -0.00424 \quad (-2.04040) \]
\[ \hat{c} = 0.000006924 \quad (2.23233) \]
\[ \hat{d} = 0.01006 \quad (2.07047) \]
\[ \hat{e} = 0.17536 \quad (1.45999) \]
\[ \hat{f} = 9.65148 \quad (11.18483) \]
\[ \hat{g} = -2.32924 \quad (-4.58564) \]
\[ S_{yx} = 3.35821 \]
\[ R^2 = 0.99503 \]