Wholesale price - retail price relationships: an aspect of price fixing in a retail gasoline market

Mark J. Vasconi

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WHOLESALE PRICE - RETAIL PRICE RELATIONSHIPS:
AN ASPECT OF PRICE FIXING
IN A
RETAIL GASOLINE MARKET

By

Mark J. Vasconi
B.A., University of Montana, 1980

Presented in partial fulfillment of the requirements for the degree of
Master of Arts
UNIVERSITY OF MONTANA
1983

Approved by:

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Dean, Graduate School

Data

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Wholesale Price - Retail Price Relationships: An Aspect of Price Fixing in a Retail Gasoline Market (69 pp.)

Director: Dr. Dennis J. O'Donnell

The purpose of this thesis was to determine if pricing patterns between retail gasoline stations in a market area were affected by the pattern of wholesale gasoline prices for stations in that market area. Daily retail gasoline prices were gathered from six retail gasoline stations. Daily wholesale gasoline prices were received from two of the six stations. The retail price information covered a period beginning on January 2, 1977 running to May 31, 1979. The wholesale prices started on January 2, 1977 and continued to March 31, 1979. These data were used in two statistical procedures, both of which are based on regression analysis: 1) Chow tests were used to ascertain if pricing patterns between stations changed over time in response to the publication of a newspaper article which alleged collusive practices in a particular gasoline market; 2) Regression analysis, in conjunction with the analysis of covariance, was utilized to determine if daily retail prices of gasoline were reflections of the daily wholesale price of gasoline. This thesis reconfirmed earlier research indicating that retail pricing patterns between stations changed over the publication of the newspaper article. Of primary significance, this thesis found that daily wholesale price of gasoline had no statistical influence on the determination of daily retail gasoline prices. The findings in this thesis further suggest the inference of collusion by retail gasoline stations located in the market area studied.
ACKNOWLEDGMENTS

Many individuals deserve my deepest appreciation and thanks for their assistance in the completion of this thesis. First, I would like to extend my sincere thanks to my thesis committee (i.e. Dennis O'Donnell, Thomas Power and Howard Reinhardt). The guidance and assistance they gave me proved to be indispensable. Next, I must thank Mr. Jerome Cate of the Attorney General's Office of the State of Montana. He was instrumental in pointing me to this topic of study. I must also extend my deepest appreciation to a fellow graduate student, James F.C. Hyde. Without his excellent tuition I might still be attempting to unlock the deep mysteries of the University of Montana's DEC 2060 computer. He also had invaluable expertise in the fine art of enjoying libations. Last, but by no means least, I want to extend my respect to all members of the Economics Department. They have all made this a worthwhile endeavor.
TABLE OF CONTENTS

ABSTRACT ...................................................................... ii

ACKNOWLEDGMENTS .................................................. iii

LIST OF TABLES ............................................................ vii

LIST OF FIGURES ........................................................... viii

Chapter

1. Introduction ......................................................... 1

   Statement of Problem .............................................. 6

2. Introduction ......................................................... 11

   Market Structure ..................................................... 12

   Theory of Perfect Competition ................................. 15

   Market Period Equilibrium ..................................... 15

   Short Run Equilibrium ........................................... 16

   Firm Eqiulibrium .................................................. 16

   Industry Equilibrium ............................................. 18

   Long Run Equilibrium ........................................... 20

   Price Determination At Retail Outlets .............. 21

   Type of Retail Outlet ........................................... 23
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Individual Dealer and Competitive Tools</td>
<td>26</td>
</tr>
<tr>
<td>Vertical Influences on Retail Pricing</td>
<td>27</td>
</tr>
<tr>
<td>Horizontal Influences on Retail Pricing</td>
<td>28</td>
</tr>
<tr>
<td>Relationship of Sales Volume to Prices</td>
<td>29</td>
</tr>
<tr>
<td>Review of Empirical Literature</td>
<td>29</td>
</tr>
<tr>
<td>Empirical Tests</td>
<td>34</td>
</tr>
<tr>
<td>3. Introduction</td>
<td>37</td>
</tr>
<tr>
<td>Data</td>
<td>37</td>
</tr>
<tr>
<td>Empirical Methodology</td>
<td>38</td>
</tr>
<tr>
<td>Conclusion</td>
<td>44</td>
</tr>
<tr>
<td>4. Introduction</td>
<td>46</td>
</tr>
<tr>
<td>Autocorrelation and The Durbin Two-Step Correction</td>
<td>46</td>
</tr>
<tr>
<td>Regression Results</td>
<td>49</td>
</tr>
<tr>
<td>Chow Tests</td>
<td>52</td>
</tr>
<tr>
<td>Analysis of Covariance</td>
<td>54</td>
</tr>
<tr>
<td>Wholesale Price Stability</td>
<td>57</td>
</tr>
<tr>
<td>Margin Analysis</td>
<td>60</td>
</tr>
</tbody>
</table>
5. Introduction .................................. 63
Conclusions ...................................... 63
Policy Recommendations ....................... 65
Limitations of Methodology ................. 66

BIBLIOGRAPHY ................................... 67
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Regression Results for ( P1^* = f(P3^<em>, P4^</em>, P5^<em>, P6^</em>, \text{ and } WP1^*) )</td>
<td>50a</td>
</tr>
<tr>
<td>2. Regression Results for ( P2^* = f(P3^<em>, P4^</em>, P5^<em>, P6^</em>, \text{ and } WP1^*) )</td>
<td>51a</td>
</tr>
<tr>
<td>3. Chow Test For Station 1</td>
<td>53a</td>
</tr>
<tr>
<td>4. Chow Test For Station 2</td>
<td>53b</td>
</tr>
<tr>
<td>5. Analysis of Covariance</td>
<td>55a</td>
</tr>
<tr>
<td>6. Analysis of Covariance</td>
<td>55b</td>
</tr>
<tr>
<td>7. Analysis of Covariance</td>
<td>56a</td>
</tr>
<tr>
<td>8. Analysis of Covariance</td>
<td>56b</td>
</tr>
<tr>
<td>9. Regression Results on ( WP1^* = f(T, T^2, \text{ and } D1) )</td>
<td>59a</td>
</tr>
<tr>
<td>10. Regression Results on ( WP2^* = f(T, T^2, \text{ and } D2) )</td>
<td>59b</td>
</tr>
<tr>
<td>11. Average Monthly Margin For Station 1</td>
<td>60a</td>
</tr>
<tr>
<td>12. Average Monthly Margin For Station 2</td>
<td>60b</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average Monthly Margin</td>
<td>60c</td>
</tr>
</tbody>
</table>

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CHAPTER ONE

Introduction

On March 28, 1979 the State of Montana filed an antitrust suit against a set of gasoline retailers operating in Missoula, Montana. The law suit was brought as a response to price fixing allegations that appeared in Missoula's daily newspaper, The Missoulian. The date of the article's publication was March 18, 1978. Dr. Dennis O'Donnell conducted economic research on the pattern of daily retail gasoline prices among six retail outlets representing five firms. These five firms were included in the law suit filed on March 28, 1979 by the Attorney General's Office of the State of Montana. Four of these five firms eventually settled out of court leaving only one firm, represented by two outlets, in the suit by the time O'Donnell's analysis was conducted.

Each of the six stations in 1979 were "independent" marketers and continue to operate as such today. The gasoline industry contains three general stages: Crude oil production; refining; and, marketing. An "independent" marketer is one which is involved in only one or two stages of the gasoline industry.
The daily retail price data used in O'Donnell's research ran from January 2, 1977 to May 31, 1979, inclusive. This is a period of 870 days for each of the six outlets. The wholesale price data used in O'Donnell's study was received from the two stations that continued in the suit. These two stations are operated under the auspices of one company. Wholesale price observations ran from January 2, 1977 to March 31, 1979, a period of 810 days.

Research was initiated by charting price changes for each station over time. This analysis produced results which, when visually inspected, showed three distinct periods of price change relationships among the six retailers. The three periods are:

Period 1 - January 2, 1977 to March 19, 1978;
Period 2 - March 20, 1978 to July 17, 1978;

The Missoulian's article appeared two days before the beginning of Period 2. The publication of this article represents a non-market event that should not precipitate alterations in the economic behavior of these six "independent" outlets; therefore, a comparison of retail price relationships among firms from Period 1 to Period 2 is of great interest. If independent competitive behavior is present in Missoula's gasoline market, the price
relationships among stations should not change from one period to the next as a result of a non-market event. The competitive process does not give firms or groups of firms power over prices; thus, they lack the ability to respond to non-market events by altering their price behavior.

Given the suggestion of three distinctly different periods, Dr. O'Donnell conducted Ordinary Least Squares regressions to statistically verify the presence of three different periods. The regressions he used were conducted on four statistical models over each of the three suspected periods. These four models were specified as follows:

(1) \( P_1 = f(P_3, P_4, P_5, P_6 \text{ and } T) \);
(2) \( P_1 = f(P_3, P_4, P_5, P_6 \text{ and } W_{P_1}) \);
(3) \( P_2 = f(P_3, P_4, P_5, P_6 \text{ and } T) \);
(4) \( P_2 = f(P_3, P_4, P_5, P_6 \text{ and } W_{P_2}) \).

Where: \( P_1 \) = daily retail price of gasoline at Station 1;
\( P_2 \) = daily retail price of gasoline at Station 2;
\( P_3 \) = daily retail price of gasoline at Station 3;
\( P_4 \) = daily retail price of gasoline at Station 4;
\( P_5 \) = daily retail price of gasoline at Station 5;
\( P_6 \) = daily retail price of gasoline at Station 6;
\( T \) = Integer value of each day from 1/2/77 to 5/31/79;
\( W_{P_1} \) = Daily wholesale price of regular at Station 1;
\( W_{P_2} \) = "  "  "  "  "  "  "  2.
It should be noted that only Stations 1 and 2 were used as dependent variables. As was stated earlier, these two stations were operated by the only firm which opted to continue in the suit brought by the State of Montana. It should also be noted that the names of each station will remain anonymous. One should also bear in mind that economic theory lacks guidelines in the task of defining time periods. Therefore, Dr. O'Donnell used an empirical approach to break these data into periods.

Regression results on models 1 through 4 indicate patterns in the estimates of R-squared and t-statistics. R-squared results are as follows:

<table>
<thead>
<tr>
<th>Model</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>$R^2 = .934$</td>
<td>$R^2 = .657$</td>
<td>$R^2 = .983$</td>
</tr>
<tr>
<td>(2)</td>
<td>$R^2 = .944$</td>
<td>$R^2 = .651$</td>
<td>$R^2 = .948$</td>
</tr>
<tr>
<td>(3)</td>
<td>$R^2 = .921$</td>
<td>$R^2 = .649$</td>
<td>$R^2 = .983$</td>
</tr>
<tr>
<td>(4)</td>
<td>$R^2 = .920$</td>
<td>$R^2 = .643$</td>
<td>$R^2 = .948$</td>
</tr>
</tbody>
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From the R-squared results, it is evident that Period 2 exhibits price relationships among firms which are very different from price relationships in Periods 1 or 3. Estimates of t-statistics, as generated on WP1 and WP2 in models 2 and 4, indicate other patterns.
Results on the t-statistic indicate that at the 5% level of significance the wholesale price of regular gasoline is not a statistically significant determinate on the retail price. In other words, the wholesale price of gasoline has no effect on the retail price for either model nor for any period. However, in Period 2, the variables representing wholesale price (WP1 and WP2) appear to be more influential contributors on retail price determination. The estimates on R-squared and t-statistics indicated alterations in relationships which determined retail price. Dr. O'Donnell then utilized Chow tests to ascertain if the relationships in each model differed from Period 1 to Period 2. The results of the Chow test indicated that for each of the four models, there was indeed a significant change in the relationships which determined retail price at Stations 1 and 2.

Dr. O'Donnell also conducted regression analysis on models (1), (2), (3), and (4) with lagged variables. The variables were lagged from one to seven time periods (i.e. days) in order to determine if daily retail prices at Stations 1 and 2 moved in lagged pattern with regards to other variables. It was found that regressions on lagged
variables proved to be no different from regressions on unlagged variables.

**Statement of Problem**

Dr. O'Donnell's results indicated that Stations 1 and 2 changed pricing behavior after the publication of *The Missoulian's* article. However, Dr. O'Donnell's research conducted only limited tests on the relationship of retail prices to wholesale prices. Using somewhat more sophisticated tools than those used by O'Donnell, the task of this thesis is to determine if the pattern of price relationships among competitors is an indication of independent competitive behavior or collusion. This task will be completed by utilizing two approaches.

First, this thesis will repeat O'Donnell's analysis by looking at the relationships among retail price movements for the six stations to see if they altered from Period 1 to Period 2 as a response to a non-market event (i.e. *The Missoulian's* article of March 18, 1978). If price relationships among stations change from Period 1 to Period 2, the possibility of collusive behavior is strong. On the other hand, if price relationships between stations do not change from Period 1 to Period 2, the inference of independent competitive behavior can be advanced. In this thesis, the specification of wholesale price variables is improved over previous work; thus the analysis will focus
on results derived from respecified variables.

Second, this thesis will determine if retail price movements are reflections of movements in wholesale prices. The relationship of retail prices and wholesale prices is only one issue pertaining to market behavior. Demand fluctuations, and the character of price fluctuations, themselves, are other issues which relate to market behavior. Therefore, in the process of drawing inference on the possibility of collusion, one must be careful to not overstate a conclusion because wholesale price-retail price relationships are only a part of the overall market process. However, if retail prices are not statistically related to wholesale prices, the inference of collusion is given added strength. Alternatively, if retail prices are shown to be statistically related to wholesale prices, the inference of independent competitive behavior is defensible.

The methodology chosen to study the issue of wholesale price relationships to retail prices incorporates regression analysis on two models:

(1) $P_1=f(P_3,P_4,P_5,P_6 \text{ and } W_{P_1})$

and

(2) $P_2=f(P_3,P_4,P_5,P_6 \text{ and } W_{P_2})$.

Because time series data for retail and wholesale prices is used, the data must first be corrected for autocorrelation. The method used to correct the data is called the Durbin.
Two-Step. (15, pg. 224-25) Once the data is corrected, regression analysis is conducted on each of the two models for each of the three periods. These regressions produce statistical results which are in turn used in Chow tests. The results of the Chow tests between periods indicate that regressions for Period 1 on each of the two models are significantly different from regressions for Periods 2 or 3. In other words, the regression for Period 1 differs from the regression which represents price behavior in Period 2 and it is also different from the regression equation of Period 3. The Chow test, which compares regression equations of Period 2 to equations of Period 3, indicates no statistical differences in the equations for each of the last two periods.

Differences in the regression equations may be due to a change in the slope of the regression line or a change in the Y-intercept term. The analysis of covariance is utilized to determine if the differences identified by the Chow tests are attributable to a change in the Y-intercept or a change in the slope of the regression line as identified by the coefficient on wholesale price in each of the two models. (15, pg. 282-83: 22, pg. 610-21) Through the analysis of covariance, it is found that the coefficients on wholesale price do not significantly change over time, nor does the term representing the Y-intercept change; therefore, one can only conclude that the differences between regressions over each period emanate from
alterations in coefficients on competitors' prices. These results confirm the analysis reported by O'Donnell in his report to the Attorney General's Office of the State of Montana. (21, pg. 13)

Another test is utilized which determines if wholesale prices alter over time. This test uses regression analysis for the purpose of finding corroborating evidence on the stability of wholesale prices. Four general models are used which try to identify possible shifts in the pattern of wholesale prices. They are as follows:

\[
\begin{align*}
(3) & \quad WP_1 = f(T, D.V.); \\
(4) & \quad WP_1 = f(T, T \text{ Squared}, D.V.); \\
(5) & \quad WP_2 = f(T, D.V.); \\
(6) & \quad WP_2 = f(T, T \text{ Squared}, D.V.).
\end{align*}
\]

Where: \( T \text{ Squared} = \) The squared value of each integer day \( (T) \);

\( D.V. = \) Dummy Variable of either 0 or 1.

Models 3, 4, 5 and 6 show that there was no shift in the pattern of wholesale costs over the publication date of The Missoulian's article. Given known alterations in price-setting relationships at Stations 1 and 2 from Period 1 to Period 2, there is no evidence which suggests that wholesale prices influenced the manner in which retail prices changed. The inference of independent competitive behavior is difficult to advance.
Chapter Two explores publications which address three major areas of the literature. First, the theory of perfect competition is outlined by presenting its basic assumptions and the price and quantity movements which the theory describes. Second, the manner in which retail gasoline prices are set will be presented through the works of Ralph Cassady Jr. and Leonard W. Weiss. Third, a review of empirical publications attempting to outline procedures which have been used in the past to make inferences regarding the presence collusive practices in the marketplace.

Chapter Three presents a review of the data utilized in the statistical tests. This chapter also articulates the exact statistical procedure used to evaluate the relationship between retail prices to wholesale prices.

Chapter Four presents the actual statistical procedure and the derived results.

Chapter Five is then a formulation of conclusions, policy recommendations, and a statement on the limitations of the approach used in this thesis.
INTRODUCTION

Chapter Two addresses five basic issues crucial to the theoretical foundation of this thesis. First, the concept of market structure is presented. In this section, the assumptions pertinent to each market setting are stated. The situation faced by retail gasoline outlets is then matched to a perfectly competitive market structure. Second, the theory of perfect competition is briefly outlined. Third, a presentation of Ralph Cassady's analysis of how retail gasoline prices are determined compared to the perfectly competitive model. In this section, the economists' abstract models are embellished to develop a model of competition descriptive of activities in a retail gasoline market. Fourth, a review of empirical literature which addresses methods of investigating the presence of collusion on prices. Fifth, is an overview of empirical approaches that one can pursue given the literature as one evaluates a retail gasoline market for signs of collusive prices setting behavior.
Market Structure

Economics generally tries to solve three basic questions: What to produce? How to produce? Who will benefit? Taken as a whole, these issues are called the economic problem. (24, pg. 1) The process of solving the "economic problem" has been greatly facilitated by distinguishing between various economic settings or market structures. Different market structures result in different answers to the problems of economics. (24, pg. 4)

Economists have classified market structure into four basic categories, representing a continuum of organization based on the number of firms in a market or industry. Aside from the number of firms in an industry, market structures are also defined by the homogeneity of the products sold. (24, pg. 10) At one extreme of this organizational continuum is monopoly. Monopoly markets are characterized by only one seller who is supplying a good or service to customers. Perfect competition lies at the other extreme on this continuum. Perfectly competitive markets are those in which many sellers function and offer as a group, a homogeneous product. Within this continuum one finds the market structures of monopolistic competition and oligopoly. (18, pg. 233) Monopolistic competition is characterized by many sellers and product differentiation. Products are differentiated by advertising, slight cosmetic alterations, and slight physical alterations. Each
competitor then sells a product that is slightly different from products marketed by other sellers. (14, pg. 308) Oligopoly markets are normally characterized by few sellers. The major point of definition in describing an oligopoly market speaks to the issue of interdependent decision making. Given the small number of firms, a decision by one firm will prompt a decision by a competitor. Therefore, all producers recognize interdependence as a fact of their business environment. (26, pg. 414)

Perfect competition, aside from having many independent sellers, each of whom markets an identical and homogeneous product, is further defined by two more requirements: Perfect knowledge of the marketplace; and, free entry and exit of firms. (10, pg. 223-24) These four requirements are sufficient structural conditions for the definition of perfect competition. (14, pg. 241)

The necessary condition for the existence of a perfectly competitive market is that each firm sees itself as a price taker in both input and output markets. (14, pg. 241) In a perfectly competitive environment, there exist so many independent firms that production decisions by one seller has no effect on the market price of inputs or outputs.

The marketing of homogeneous products insures that the consumer is indifferent between two sellers. (18, pg. 234) Perfect knowledge implies that all consumers are fully aware of all prices in a market. (20, pg. 237). Free entry and exit
is present and is associated with the free mobility of resources. (18, pg. 235) Mobility of resources speaks to the ability of resource inputs to move freely into or out of a market or a particular use. It further implies that labor is free to move from one job to another and that inputs are not monopolized by any one producer or owner. (10, pg. 224)

Gasoline retailing is related to the conditions which define a perfectly competitive market. (5, pg. 336-45) The situation faced by retailers in Missoula, Montana approximates, to a high degree, the market setting described by perfect competition. First, there are many gasoline retailers in Missoula, Montana. Of the over sixty retailers, approximately 50% are independent marketers. (personal observation) Second, the gasoline sold in Missoula is physically homogeneous among all competitors. All gasoline sold in Missoula comes from refineries in Billings, Montana via the Yellowstone pipeline. (Court testimony of J. Gary Louqet, June 4, 1982) The Yellowstone pipeline starts in Billings and runs west to Moses Lake, Washington. Third, consumers in Missoula have, if not perfect knowledge, very good knowledge on the prices of regular gasoline at most outlets in the city. Most retailers post the price of self-service regular on large signs which readily relay prices to passing motorists. Fourth, entry and exit in Missoula's gasoline market does not appear to be difficult. The fact that free entry exists in the Missoula market is demonstrated by observing that
Missoula has gasoline outlets operated by "major" brand companies, "independent" marketers, convenience stores, and even a butcher shop. Leonard Weiss confirms the general situation of easy entry into a gasoline market by stating that "Would-be proprietors need very little capital to enter the business, and, since the skills involved are widely known and hope springs eternal, there is practically no limit to the number of potential operators as well as stations." (27, pg. 413)

The Theory of Perfect Competition

The model of perfect competition outlines the determination of market price for both the firm and the market in three separate time periods. The shortest time period is known as the market period followed by the short run and the long run. (18, pg. 236) The distinction between time periods is dependent upon the length of time it takes a firm to vary inputs. In the market period, output is fixed by the supply of resources at hand. In the short run, output can vary by changing the utilization of variable inputs. In the long run, output is variable because all inputs, can be changed. (10, pg. 226)

Market Period Equilibrium

Given that input levels are absolutely fixed for a particular time horizon, a firm cannot instantaneously change its output levels. (20, pg. 238) In the market period, a
firm can sell the quantities it has at the going market price. (18, pg. 236) The industry supply is simply the horizontal summation of each firm's supply. Therefore, industry supply is fixed during a market period while price is strictly determined by the level of demand the industry is facing. Equilibrium is identified by the price at which the market is cleared. (10, pg. 226) Price movements are completely dictated by demand for the product. To reiterate, in a market period, supply alone determines equilibrium quantity while demand alone determines equilibrium price. This situation is an extreme contrast to short run and long run conditions. In the short run or long run, equilibrium prices and outputs are determined simultaneously by the interaction of demand and supply.

**Short Run Equilibrium**

**Firm Equilibrium**

The determination of short run equilibrium begins with an understanding of a firm's supply decisions. In markets where firms are price takers (i.e. perfectly competitive markets), a firm may sell as many units of output as it can at a given and fixed price. (2, pg. 313) At first glance, this is a rather intuitive and simple statement. However, a firm can only sell as many units as it can supply. The ability of a firm to supply a particular level of output is defined
by its supply schedule. To adequately understand what represents a supply schedule the concept of marginal cost must be presented.

Marginal cost is the additional cost a producer incurs to produce one extra unit of output. (14, pg. 226) The concept of marginal cost is important because it embodies a statement on the kind of technology a firm has and the costs of inputs utilized in production. (20, pg. 195-96) In most production techniques, the additional cost of producing one additional unit of output declines over low levels of production, then, after reaching some point of output, begins to rise as output is increased. (14, pg. 226) For a perfectly competitive firm, the relationship of marginal cost to output levels, above minimum marginal cost, is known as the supply schedule. The supply schedule is in turn an expression of how much a firm will be able to supply at a given price.

Given a supply schedule derived from marginal cost relationships to output levels, a firm's equilibrium output is determined by the market price. (18, pg. 237) A firm's output is in equilibrium where the market price is equal to the marginal cost of production. (10, pg. 233) As the market price moves, equilibrium output will also move. When price goes up, the quantity supplied will go up. Likewise, when price goes down, the quantity supplied will also go down.
In the short run the only adjustment a firm can make is in the quantity of output it can supply to the market. The price which a perfectly competitive firm charges is determined by the market demand. Therefore, price is set independent of a firm's desired price or its internal production process.

**Industry Equilibrium**

As with the short run equilibrium of the firm, where equilibrium quantity is defined by the market price and a firm's supply schedule; short run industry equilibrium is defined in the same manner. The only difference in formulating industry equilibrium emanates from the derivation of the industry supply schedule.

In the simplest case, the short run industry supply schedule is a summation of individual firms' supply schedules (i.e. marginal cost schedules). However, this technique of simple summation is appropriate only when an expansion of industry supply does not affect input prices. Normally when all firms increase output simultaneously, there is a noticeable effect on input prices.(14, pg.257)

To illustrate the effect of rising input prices with expanding output, one can examine farming as an industry. If one farmer were to increase output (i.e. supply) by increasing the level of inputs, there would be no appreciable change in the market prices of tractors,
fertilizer or seed. However, if all farmers increased output through increasing inputs, a producer's marginal cost schedule will shift upwards. This means that for any one additional unit of output, the additional cost will also increase over previous levels. (10, pg. 237) As marginal cost shifts upward, the amount of quantity supplied at any one price will fall from previous output levels. (10, pg. 237) Consequently, the derivation of an industry supply schedule, when based upon mere summation of individual supply schedules, will not be an accurate representation of potential output at a given market price.

Short run industry equilibrium in price and quantity is achieved when demand and supply are equal. At the equilibrium price, the firm will adjust its production to equilibrium levels of output. When both the industry and firm are in equilibrium, it is known as full equilibrium. (14, pg. 259) Given full equilibrium, where firms are earning positive profits and there is no entry of new firms, output level will not change.

In a market where there is full equilibrium, the market supply, in the short run is fixed. Therefore, the only determinate of equilibrium price is the quantity demanded. (10, pg. 239) The quantity demanded of a particular good or service is a reflection of income, consumer tastes and preferences, and demographic considerations of population growth. (26, pg. 88) Therefore, the derivation of an equilibrium price through adjustments in demand has a random
element. Preston and King hold that competition in a market can be statistically appraised by analyzing regression residuals. (23, pg. 803) A residual is defined by the difference between an observed value and the predicted value of a dependent variable as generated by a regression procedure. If the residuals demonstrate a normal distribution, they are random and representative of competitive market behavior. If the residuals demonstrate a distribution which is not random, the inference of collusion is given credibility. (23, pg. 803-04)

Dr. O'Donnell employed a "goodness-of-fit" technique to analyze the residuals of the regressions he produced. The technique he used was the Kolmogorov-Smirnov test. He found that the residuals of the regressions did not conform to a normal distribution. This suggests that some force came between the buyer and seller that biased the relationships away from a competitive process.

**Long Run Equilibrium**

Given that in the long run all inputs are variable, including plant size, long run firm adjustments are dictated by the plans of other firms. If profits in an industry are positive, existing firms may increase plant capacity, new firms may enter the industry, or both. Expansion of industry output will reduce the market price. As output continues to expand the market price will continue to fall.
With falling market prices, profits will fall for firms in the industry. Unless industry output levels are reduced, profits will continue to fall to levels where losses are incurred industry-wide. (18, pg. 244) As losses continue to mount, firms will leave the industry or firms will reduce their output levels. Firm exit will continue until profits are neither positive nor negative.

A firm operating in the short run will adjust its output levels to a point where the market price is equal to its marginal cost. Movements of this type are profit maximizing. However, in the long run, plant capacity is variable and the entrepreneur can select the industry in which his capital will operate most profitably. (10, pg. 246) Long run equilibrium, where excess profit is zero, is reached when price is equal not only to the short run marginal cost, but also to long run marginal cost. When this long run condition is satisfied, firms maximize profits and entry is discouraged. (2, pg. 315)

Price Determination At Retail Gasoline Outlets

Before moving into a discussion on how retail gasoline prices are determined, some distinctions between theory and practice must be made. Gasoline retailing in Missoula conforms to the assumptions of perfect competition in terms of the number of participants, the sale of a homogeneous product, free entry and exit, and perfect knowledge.
However, retail price determination has elements of price setting and interdependence which are in direct contrast to the criteria of independent action and price taking as advanced in the theory of perfect competition. This does not mean that the theory of perfect competition has no place in assessing the problem at hand. In fact, over the long run, the theory of perfect competition is a very useful tool for describing the relationship of retail prices to costs (i.e. wholesale prices). This long run relationship shows that retail prices must approximate wholesale prices, otherwise there will be excessive entry or excessive exit. In the long run, the theory of perfect competition provides a standard by which market behavior can be judged. In the case at hand, retail price determination, in practice, differs from price determination in theory.

Not only does the theory of perfect competition differ from the realities of retail price decisions, but the concept of competition advanced by theory has little relation to the concept of competition advanced in antitrust law. Competition, as modeled by antitrust legislation, implies the absence of monopoly power or practices which secure monopoly profits, one of which is collusion among sellers. This definition has great collusion and is not nearly as specific as theoretical definitions for competitive behavior.
Ralph Cassady, Jr. in *Price Making and Price Behavior in the Petroleum Industry* has analyzed the forces which determine retail gasoline prices.

An outlet's retail gasoline pricing decisions are a reflection of a number of considerations:

1. Prices are a reflection of the type of retail outlet.
2. Prices are determined, to an extent, by the type of competitive methods available to the retailer.
3. Prices are set by considering the vertical influences upon a dealer.
4. Price levels are affected by horizontal pressures (i.e. Collusion).
5. Prices are a reflection of the gasoline volumes normally marketed by a retailer.

Each of these five considerations are presented in this section.

**Type of Retail Outlet**

Retail outlets differ markedly from one another. The difference from one to another is usually defined by the terms of the supplier-retailer relationship. Normally there are three classes of retail operations. They are classified
as follows:

A. Company owned and operated stations. This type of relationship is present when the supplier not only owns the station, but also operates the station via an employee.

B. Company-owned but lessee operated stations. In this operating scheme, the supplier owns the outlet, but leases it to a dealer.

C. Dealer-owned and operated. Here, the dealer who operates the station is also the owner. The dealer is independent of the supplier except for product contracts.(5,pg.236)

A large proportion of outlets are administered under the company-owned, dealer-operated option. Many companies will buy locations in a city and lease them to a dealer. This enables a company to blanket a market area. This form of operation does not rely upon less predictable methods of acquiring a good location. These company-owned, dealer-operated stations are usually more profitable than others whose product supply may not be as reliable.(5,p g .237)

Possibly the largest segment of retail stations are independently owned and operated. In this situation, suppliers only have a contractual relationship to dealers.
However, in spite of their large numbers, independents market a smaller share of gasoline than do "major" oil companies. (5, pg. 238)

Control relationships between retailers and suppliers are important because different relationships dictate different opportunities for rivals to acquire locations. If a supplier owns and operates a station, the chances for a competitor to acquire the location are small. If a supplier leases the property from its owner, the risk of losing the location upon expiration of the lease is high. The most promising market for rivals is one characterized by many independent stations. These stations are normally bound to a supplier through product contracts. Many rivals may attempt to acquire an independent station by proposing better contractual terms. (5, pg. 238)

The differences in supplier-operator relationships also manifest themselves in pricing responsibilities. At company-owned and operated stations, pricing is solely determined by the supplier. At company leased stations the lessee normally sets prices. At owner operated outlets, the owner has full responsibility for pricing policies. (5, pg. 239)
The Individual Dealer and Competitive Tools

The individual dealer has a set of competitive tools which aid in price determination and the expansion of sales. First, a dealer may rely on appeals such as advertising to attract customers. Second, a dealer may offer more ancillary products to gain consumer patronage. Third, efforts to increase sales may rely on price reductions of ancillary products rather than gasoline. Fourth, selective or secret price concessions may be made to gain or maintain business. Fifth, a dealer may initiate direct price reductions on gasoline.(5, pg. 240)

The competitive tools expressed above must be considered in terms of a retailer's market situation. Considerations must be made pertaining to a number of factors. These factors include the level of competition, profit requirements, product line reputations, and the degree of a rival's influence on pricing decisions. Most importantly, a retailer must base a great deal of his competitive efforts on price adjustment. If his pricing system is not flexible, he will lose volume during periods of falling market prices or he will lose product during in a period of rising market prices. Therefore, given a particular location, a particular number of competitors, etc. the competitive tools a dealer uses are largely predetermined by the market environment.(5, pg. 241)
As an example, small independent dealers have to sell gasoline below price charged by company owned stations. A lower market price, relative to a price at a company owned station, is necessary to make up for a poor location and few ancillary services. (5, pg. 241)

Elasticity of demand is another consideration which dictates the appropriate competitive approach. While the market elasticity of demand for gasoline is generally low (i.e. inelastic), the elasticity of demand at a particular station is generally high. This means that price levels are a very important tool for all gasoline dealers, especially for independent outlets. Company-owned and operated stations will be reluctant to engage in blatant price competition for fear of triggering harmful price wars. (27, pg. 412)

In conclusion, a retailer has a set of competitive tools at his disposal. The choice of tools, however, is limited by market factors and demand elasticities.

**Vertical Influences on Retail Pricing**

In any discussion of gasoline pricing, one must consider vertical influences such as wholesale price and the policies of the supplier. Generally the wholesale price of gasoline is closely tied to the retail price a dealer charges. (5, pg. 243) Any change in retail wholesale price is normally reflected by a change in retail prices. However, a
dealer may be reluctant to pass on a one cent price increase fearful that sales volume will be reduced, thereby yielding lower revenue. (5, pg. 244)

A supplier's pricing policies also effect retail prices. Given high elasticity of demand at a particular station, a supplier will retain some degree of control over pricing decisions at retail operations. (5, pg. 244) This is necessary to avert possible price wars initiated by a retailer's sloppy price moves. Therefore, a supplier may utilize one of the following policies:

(1). The supplier may exert complete control over price levels.

(2). The supplier may grant the dealer complete pricing authority.

(3). The supplier may retain an interest in setting prices. This is usually done by giving advice to the retailer. (5, pg. 245)

Of the three policies a supplier may employ, the third is utilized most frequently.

**Horizontal Influences on Retail Pricing**

One cannot ignore the fact that at times a dealer's pricing has been influenced by prices at other stations or other horizontal pressures such as collusion. (5, pg. 246)
Dealers must protect margins in order to prosper, trade associations exist in many localities to protect the common interests and goals of the proprietors.

Certain vehicles of horizontal pricing, such as parallel pricing between competitors, are not per se illegal unless an agreement is present. (5, pg. 247)

**Relationship of Sales Volume to Prices**

High elasticity of demand for a particular station implies that a small alteration in price will result in a significant change in the quantity demanded. Therefore, it is very common to observe a station cutting its price in an effort to increase sales volume and possibly revenue. As long as a price reduction is not met by competitors, a station will increase its volume. However, if a price cut is matched by other dealers, sales volume will not change significantly. (5, pg. 252) This is caused by a difference in elasticity between the market and a particular station. (27, pg. 411)

**Review of Empirical Literature**

Richard Posner, a leading authority in antitrust economics has stated that "Economically significant collusion should leave some visible traces in the pricing behavior of the market,..." (17, pg. 1) Using Posner's
hypothesis, John M. Kuhlman employed standard statistical measurements of means and frequency distribution to study price behavior among firms charged with collusion in an unidentified bid-rigging suit. This study used data recorded over a time period of six years for a sealed bid market.

Kuhlman divided the data into four periods. He then analyzed means and frequency distributions to identify the dispersion of bid prices from firm to firm.

Kuhlman's analysis found that in Periods 1 and 2, there was very little dispersion, while in Period 3 the dispersion increased slightly as result of firm entry. In Period 4 the level of dispersion increased significantly. (17, pg. 17) The increases in price dispersion in Period 4 are interesting because the filing date of the antitrust suit initiates the beginning of the fourth and final period.

Prior to the filing date of the law suit, over 50% of the market showed a price dispersal of less than 2%. After the filing date of the law suit, during Period 4, the number of firms registering a 2% price dispersal dropped to under 25%. This decrease was accompanied by an increase in the number of firms which had larger differentials. (17, pg. 8)

Kuhlman concludes his analysis by advancing the proposition that variations in price dispersions after a non-market event, such as the filing of a law suit, are "visible traces" of effective collusion. (17, pg. 18)
John Kuhlman's work on the issue of statistical tracking of prices has spawned work by other authors. One such author, Allen W. Blair, has promoted the use of Kuhlman's methodology. He basically produces discussion which centers on the fact that uniform pricing is an indication of horizontal pricing influences. (4, pg. 686) However, he qualifies his discussion with the fact that uniform prices are to be expected if costs among competitors are equal. The difficulty of interpreting uniform prices as evidence of collusion rests with understanding normal market operations. As a result of his qualification, a computer becomes a useful tool in discovering relationships which are not explained by market forces.

Since market forces play a central role in pricing decisions, one must examine a market environment before claiming that price uniformity is an indication of illegal horizontal pricing activities. (4, pg. 687) The possibility of collusion is normally thought to be high in oligopoly markets where interdependent decision making is a defining characteristic. However, interdependence dictates that price adjustments be made as a response to a competitor's decisions. Economists disagree over the question of uniform prices as a possible indicator of collusion in oligopoly markets. (4, pg. 689)

The argument concerning uniform prices and their relationship to collusion, when considering many firms and many buyers, is somewhat more settled, at least in Blair's
analysis. He feels that in a perfectly competitive market uniform prices are strong indicators of collusive practices. Blair states:

In a market composed of many buyers and sellers, the economic pressures resulting from interdependence are absent. Thus, if price uniformity occurs in a normal marketplace the inference of collusion is strengthened because the oligopolistic forces are not in effect. Collusion is easier to detect and adherence to the price-fixing agreement is more difficult to enforce because there are a larger number of participants.(4,pg.689)

One must be aware of the fact that Blair's analysis of uniform prices is only revealing in the instance of divergent costs among competitors. If costs are equal between competing firms, one would expect uniform prices. Given this point, one can see that costs for each gasoline retailer studied herein are probably different. Different costs are likely because of different hours of operation and different ancillary products.

Blair moves on to suggest market characteristics which promote horizontal pricing activities. It is his feeling that price tracking analysis should focus on markets characterized by a homogeneous product, inelastic demand, stable technology, sealed bids and substantial barriers to entry. However, he does not suggest limiting price tracking analysis to markets that completely fit the characteristics just mentioned.(4,pg.691) One can easily see that the situation facing gasoline retailers is one which can be
addressed by Kuhlman's empirical methodology. The gasoline sold is of a homogeneous quality, market demand is inelastic (6, pg. 380) and the technology necessary to market gasoline seems to be relatively stable. However, Missoula's gasoline market does not operate on a sealed bid basis and one might suspect that the barriers to entry into the gasoline retailing business are not high (27, pg. 431).

When a price tracking analysis is attempted, Blair indicates particular relationships which should be studied. These relationships include the detection of (1) geographic market divisions: (2) periodicity in price behavior which follows a systematic pattern over time: (3) price relationships among sellers: (4) price relationships over space: (5) price relationships over time. (4, pg. 692) Blair concludes his analysis with a presentation on Kuhlman's results.

Dale R. Funderburk has also studied competitive behavior from the approach suggested by Kuhlman. (12, pg. 62) He feels that price tracking is a valid approach because the discovery of a "Hot Document" is very rare. He, like Kuhlman, used objective market data in studying competition in Oklahoma's liquid asphalt industry. Funderburk found that sales of asphalt to the State of Oklahoma showed uniform prices between all firms considered. As in Kuhlman's study, Funderburk found that price uniformity was reduced after the filing of an antitrust suit against members of the liquid asphalt industry in
Lee E. Preston and Benjamin King analyzed price and cost data to address the question of competition. Instead of tracking prices they utilized correlation analysis to discover if prices were related, over time, to costs. They also used time series data in regression analysis where the residuals were examined by a "goodness-of-fit" test. If residuals demonstrated a random pattern (i.e. normal distribution), an inference of competitive behavior was strengthened. However, if regression residuals demonstrated a non-random pattern, a departure from competitive behavior was suggested. The analysis of residuals relates back to the earlier assertion on the random manner in which a market price is determined at full equilibrium. Since supply is fixed in the short run, the only other influence on short run equilibrium price is short run market demand. Market demand is determined to a great degree by tastes and preferences of the consumer which are random decisions at a given level of income.

Empirical Tests

Kuhlman's methods will be used to determine if price behavior among retail gasoline outlets in Missoula changed from one period to the next. One can use Chow tests on regression estimates to discover if any alterations in
pricing relationships between competing firms occurred as a result of a non-market event: The Missoulian's article.

Cassady's analysis presents the possibility for some interesting statistical tests. Since gasoline prices are related to influences such as wholesale prices and competitors' retail prices, one can use regression analysis to determine their relative contributions to a dealer's retail price offerings.

To assess the relative contributions of wholesale price and competitors' retail prices on one station's pricing decisions, one should use daily retail and wholesale price levels. Given a certain degree of retail price matching and the stated significance of wholesale prices one should expect to find, in a competitive gasoline market, significant t-statistics on both retail and wholesale price variables. If competitor's retail prices are significant determinants on a firm's retail price, while wholesale prices are not significant determinants, the presence of vertical influences should be discounted. In this case the possibility of horizontal agreements should be closely scrutinized.

Given Cassady's assertion that dealers may lower their margin to save either market shares or increase sales volume, one can analyze monthly margins to assess the competitive position of a firm. As competition increases, a firm, in the short run, is likely to decrease margins and not pass on a wholesale price increase. As competition
decreases, a firm, in the short run, is likely to increase its margin. However, over the long run, as was previously stated, retail prices must approximate wholesale prices or there will be entry or exit from the market.

Therefore, using regression analysis on retail and wholesale prices, and an analysis of margins, one can address the possible presence of a number of influences which affect price determination. To reiterate, levels of competition can be assessed by an analysis of margins, while the presence of vertical or collusive influences can be assessed by proper regression analysis.
CHAPTER THREE

Introduction

Chapter Three has two purposes. First, is the summary of data used in the analysis. This summary describes where the data came from and what it contained. Second, is a description of the methodology which will attempt to ascertain two things: First, did the article in The Missoulian, a non-market event, have any relationship to possible changes in the price relationships among the six outlets studied: Second, did movements in daily retail prices at Stations 1 and 2 have a relationship to wholesale gasoline prices at these two stations?

Data

Throughout the literature review of Chapter Two, reference was made to analyses which used retail and wholesale prices; Retail and wholesale prices are used in this thesis. The data utilized comes from five retail gasoline firms operating six outlets in Missoula, Montana. The data on retail prices comes from daily station reports where the daily price of regular gasoline was recorded. These daily reports yielded retail price data from January 2, 1977 to May 31, 1979. Wholesale prices for regular
gasoline were received from only two stations, each operating under the sanction of one company. The wholesale price data for both stations runs from January 2, 1977 to March 31, 1979. Problems with missing values were encountered with the wholesale price data. The missing observations were removed; therefore, analysis on Station 1 uses 725 observations while Station 2 uses 738 observations. Each daily observation has six retail prices and two wholesale prices. The data was placed into a file in the University of Montana's DEC 2060 computer.

Empirical Methodology

The empirical tests used to investigate if price relationships among stations reveal independent action or collusion center on regression techniques and Kuhlman's methodology. Regression analysis, coupled with Chow tests, enables one to see if the price relationships among stations altered after the publication of The Missoulian's article. Regression analysis can also determine the relative contributions of competitors' prices and wholesale prices on the determination of retail prices at Stations 1 and 2. Given Cassady's presentation, one should expect to see competitors' retail prices and wholesale prices at Stations 1 and 2 statistically significant determinants of retail prices at Stations 1 and 2. Regressions are conducted on two regression models:
(1) \[ P_1 = b_0 + b_1(P_3) + b_2(P_4) + b_3(P_5) + b_4(P_6) + b_5(WP_1) + e_i, \]

and

(2) \[ P_2 = b_0 + b_1(P_3) + b_2(P_4) + b_3(P_5) + b_4(P_6) + b_5(WP_2) + e_i, \]

Where:  

- \( P_1 \) = daily retail price of regular at Station 1,
- \( P_2 \) = daily retail price of regular at Station 2,
- \( P_3 \) = daily retail price of regular at Station 3,
- \( P_4 \) = daily retail price of regular at Station 4,
- \( P_5 \) = daily retail price of regular at Station 5,
- \( P_6 \) = daily retail price of regular at Station 6,
- \( WP_1 \) = daily wholesale price of regular at Station 1,
- \( WP_2 \) = daily wholesale price of regular at Station 2,
- \( e \) = error term.

However, before any regression analysis can be conducted, the data has to be corrected for autocorrelation. Because the data is recorded sequentially over time, an observation on Day 2 will be influenced by an observation on Day 1. The presence of autocorrelation in the data will bias the calculation of the residual sum of squares, therefore, regression statistics such as the F-statistics, t-statistics and R-squared will be incorrect.\(^{(15, pg. 208-11)}\) The Durbin Two-Step is a technique which corrects a data set for autocorrelation. Therefore the Durbin Two-Step is employed to correct the data for autocorrelation, then models (1) and (2) are estimated.
If one wants to follow Kuhlman's analysis, the stream of data has to be broken into a particular number of time periods. Here the data on retail and wholesale prices is broken into three periods by using the same technique as Dr. O'Donnell. Specifically, price changes for each station were charted over time to see if the pattern of price changes among all stations exhibited alterations over the publication of *The Missoulian's* article. The first period is from January 2, 1977 to March 19, 1978. Period 2 runs from March 20, 1978 to July 17, 1978. Period 3 goes from July 18, 1978 to March 31, 1979. Price behavior in Period 2 is important because it begins shortly after the publication of *The Missoulian's* article. This newspaper article alleged that horizontal price activity existed in Missoula, Montana. This article is also a non-market event which should not trigger alterations in price relationships from Period 1 to Period 2 if the guidelines of independent competition are followed.

Six regression estimates are produced, one for each of the three periods and one for each of the two models. Given these regressions, in order to follow Kuhlman's methodology, the regression results of each period are compared with other periods to discover if the price relationships are stable from one period to the next. A statistical test which checks the stability in regression relationships over time is a Chow test. (15, pg. 164-65). A Chow test uses the sum of squared residuals of three separate regression
equations to discover if regression relationships change from period to period. The statistical formulation of a Chow test is given below (15, pg. 166).

\[ F^* = \frac{[\sum e^2_p - (e^2_1 + e^2_2)]/K}{(\sum e^2_1 + \sum e^2_2)/(n_1 + n_2 - 2K)}. \]

Where:

\[ \sum e^2_p = \text{Sum of Squared Residuals for a Pooled Sample}; \]
\[ \sum e^2_1 = \text{Sum of Squared Residuals for Sample 1}; \]
\[ \sum e^2_2 = \text{Sum of Squared Residuals for Sample 2}; \]
\[ n_1 = \text{Number of Observations in Sample 1}; \]
\[ n_2 = \text{Number of Observations in Sample 2}; \]
\[ K = \text{Number of regression coefficients plus one for intercept}. \]

The results of a Chow test are interpreted in exactly the same manner as those for an F-test. If \( F^* \) is greater than a critical value, the regression relationships between two periods are different. If \( F^* \) is less than a critical value, the regressions between two periods are the same and the estimated relationships are continuous and without shifts. (15, pg. 166).

If a Chow test between two periods indicates an alteration in the regression relationships of either model (1) or model (2), one can assume that price relationships between Station 1 and Station 2 changed. This would correspond to Kuhlman's approach and hints at the possible presence of collusive behavior for which further tests...
should be conducted.

Significant Chow tests can be explained by either a change in the Y-intercept (i.e. the constant term) or a change in the slope of a regression (i.e. coefficients of independent variables in a regression). An analysis of covariance can determine which change occurred over the relevant time period. (15, pg. 282-83) Given a change in the relationships between the dependent and independent variables from one period to the next, a possible explanation may lie with an alteration in the relationship between prices at Stations 1 and 2 and wholesale prices at Stations 1 and 2. Covariance analysis can isolate possible changes in the relationship of retail prices and wholesale prices at Stations 1 and 2. (22, pg. 610-23) The analysis of covariance is also useful for checking the movements in the sign of an estimate over time or the sign of a t-statistic. If it is seen that wholesale prices had no effect on the alteration of the regressions from period to period, an alternative hypothesis of collusive activity is given more credibility. If, on the other hand, the differences between regressions are attributed to differences in the relationship of retail price and wholesale prices, it is possible to advance the inference of independent competitive behavior.

If the analysis of covariance shows that wholesale prices are not responsible for the differences between regressions, it would be interesting to observe the
stability of wholesale prices over time. If wholesale prices are stable over time, this would serve as corroborating evidence to the fact that wholesale price influences are not responsible for differences in regressions as identified by Chow tests. Exploring the stability of wholesale prices is accomplished by the following models:

(3) \[ WP1 = b_0 + b_1(T) + b_2(D.V.) + e_i; \]
(4) \[ WP1 = b_0 + b_1(T) + b_2(T \text{ Squared}) + b_3(D.V.) + e_i; \]
(5) \[ WP2 = b_0 + b_1(T) + b_2(D.V.) + e_i; \]
(6) \[ WP2 = b_0 + b_1(T) + b_2(T \text{ Squared}) + b_3(D.V.) + e_i; \]

Where: \( WP1 = \) Daily wholesale price of regular at Station 1;
\( WP2 = ^\text{ " " " " " " 2;} \)
\( T = \) Integer value of each day from 1/02/77 to 3/31/79;
\( T \text{ Squared} = \) Squared integer value of each day from 1/02/77 to 3/31/79;
\( D.V. = \) Dummy variable of either 0 or 1.

To complement regression analysis and Chow tests, one can attempt to assess the movements in the average monthly margins at Station 1 and 2 to check the competitive situation faced by these two stations. It is possible to
observe the movements in monthly margins in Period 2 relative to margin adjustments in the same months of the previous year. If margins in Period 2 show the same adjustment pattern as the same months in the previous year, one can discount the presence of collusive influences. On the other hand, if margins in Period 2 show more extreme adjustments than in the same period for the previous year, the inference of collusive activity is strengthened.

**Conclusion**

In order to apply Cassady's analysis to the six stations studied in this thesis, one can incorporate Kuhlman's price tracking procedure with Preston and King's analysis of the relationships between prices and costs. These procedures are attempted after first correcting the data for autocorrelation. Then, regression analysis is conducted for two stations over three time periods. Chow tests are used on the regression results to discern if the regressions on each period are significantly different from other periods. If the regressions are different, the analysis of covariance will check to see if the differences come from alterations in the relationship of retail prices to wholesale prices. If covariance analysis shows that differences in regressions do indeed come from variations in the relationship of retail to wholesale prices, then, one can only conclude that the changes in pricing relationships...
between firms are not due to collusive behavior. If wholesale and retail price relationships do not change over the periods, the inference of horizontal pricing activity such as collusion, is strengthened.

Assuming that no alteration is identified in retail and wholesale price relationships, regressions are conducted which examine the stability of wholesale prices over time. Out of this analysis one might be able to produce corroborating evidence to the fact that altering price relationships between stations had nothing to do with wholesale prices.

The empirical analysis is concluded with a review of average monthly margins. If margins in Period 2 indicate the same movements as margins in the same months of the previous year, evidence of competitive behavior is strengthened. On the other hand, if margins in Period 2 show different movements relative to margins for the same months in the previous year, the inference of collusion is reinforced.
CHAPTER FOUR

Introduction

Chapter Four gives step by step results of the methodology put forth in Chapter 3. First, a description of the procedure which corrects for autocorrelation. Results are then presented. Second, an articulation of the regression results derived for equations which estimate the retail price of regular gasoline at Stations 1 and 2. Third, a description of the Chow tests used on the regression results generated in the second part of this analysis. Fourth, a presentation of the results generated by the analysis of covariance. Fifth, presentation of the findings of the regressions on wholesale price stability. Last is a presentation of the analysis of average monthly margins at both Stations 1 and 2.

Autocorrelation and The Durbin Two-Step Correction

Autocorrelation is a statistical phenomenon associated with time series data. Given that in most time series observations, the value of the observation on Day 2 is related to the value of the observation of Day 1, the observations are not independent. Therefore, the
independence criterion of Ordinary Least Squares regression is violated. The consequences of autocorrelation ultimately manifest themselves in biased variances of the parameter estimates and the error term, thereby increasing the likelihood of incorrect inference based upon biased statistical indicators. (15, pg. 208-11) A quick check on the degree of autocorrelation is given by the Durbin-Watson statistic. Positive autocorrelation is indicated by the Durbin-Watson statistic when it is "close" to or equal to zero. Negative autocorrelation is indicated when the Durbin-Watson statistic is "close" to four. When the Durbin-Watson statistic is "close" to or equal to two, there is no autocorrelation. (3, pg. 259) A word of caution should be advanced pertaining to the use of the Durbin-Watson statistic. In a model which uses lagged variables, the Durbin-watson statistic is a biased indicator of autocorrelation. One should then utilize the Durbin 'h' statistic. (3, pg. 260-61)

One procedure developed to correct for autocorrelation is the Durbin Two-Step. The Durbin Two-Step is a method which uses, in the first step, a lagged version of the original model to estimate the numerical form (i.e. correction factor) of the data's autocorrelation. Once the correction factor is generated, the second step uses the correction to transform the original data into new data which has no autocorrelation. (15, pg. 224-25) The procedure is as follows:
Given the original model:

\[ P_1 = b_0 + b_1(P_3) + b_2(P_4) + b_3(P_5) + b_4(P_6) + b_5(WP_1) + e_i, \]

Step one uses regression analysis on the model,

\[ P_1 = b_0 + p(P_{1, t-1}) + b_1(P_3) + b_2(P_{3, t-1}) + b_3(P_4) + b_4(P_{4, t-1}) + b_5(P_5) + b_6(P_{5, t-1}) + b_7(P_6) + b_8(P_{6, t-1}) + b_9(WP_1) + b_{10}(WP_{1, t-1}) + e_i. \]

Where 'p' is an estimate of the correction factor necessary for transformations. After doing step one on the lagged model, \( p = .47642 \). Step two uses p to transform the original data in the following manner:

\[
\begin{align*}
P_{1,*} &= [P_1 - p(P_{1,t-1})] \\
P_{2,*} &= [P_2 - p(P_{2,t-1})] \\
P_{3,*} &= [P_3 - p(P_{3,t-1})] \\
P_{4,*} &= [P_4 - p(P_{4,t-1})] \\
P_{5,*} &= [P_5 - p(P_{5,t-1})] \\
P_{6,*} &= [P_6 - p(P_{6,t-1})] \\
WP_{1,*} &= [WP_1 - p(WP_{1,t-1})] \\
WP_{2,*} &= [WP_2 - p(WP_{2,t-1})].
\end{align*}
\]

Regressions are then conducted over three periods using each of the following equations: (15, pg. 229)

\[ P_{1,*} = b_0 + b_1(P_{3,*}) + b_2(P_{4,*}) + b_3(P_{5,*}) + b_4(P_{6,*}) + b_5(WP_{1,*}) + e_i, \]
Regression Results

The six regressions developed by using equations (1) and (2) of the previous section are summarized in Tables 1 and 2. Table 1 shows results for Station 1 while Table 2 shows results for Station 2. In Table 1, results of the t-statistic, for Period 1, show that daily retail prices on regular gasoline for Stations 3, 4, 5, and 6 are all significant contributors to the price of regular gasoline at Station 1. While the competitors' daily prices are significant determinates on Station 1's daily price, Station 1's wholesale gasoline prices are not. The R-squared results indicate very good results with an R-squared of .95178 while the F-statistic is equal to 1373.90238. The F-statistic indicates that the entire regression equation is statistically significant. The Durbin-Watson statistic, given by D-W in Table 1 is equal to 1.89. This indicates that there is no autocorrelation in the equation. Although the D-W does not equal 2, one can suspect that there is no positive autocorrelation at the 1.0% level by using the equation of $d < d^* < (4-d)$ where $d$ is equal to 1.65 with five independent variables. (15, pg. 215 and 666) Therefore, $1.65 < 1.89 < 2.35$. Given no autocorrelation, the results on the t-statistics, F-statistic, and R-squared are
reliable.

Period 2 of Table 1 indicates peculiar behavior when compared to the results of Period 1. First, the estimate of R-squared falls to .35684 while the F-statistic drops to 12.42. It should be noted that the value F-statistic is still significant. Second, the t-statistic on each independent variable also exhibits peculiar behavior. In Period 1, all competitors' prices were significant variables in the regression. In Period 2, however, prices at only Stations 3 and 5 remained significant determinates on the price of gasoline at Station 1. Station 1's wholesale gasoline price remains an insignificant determinant on its retail price. The D-W statistic of 2.23 indicates no autocorrelation. While higher than that of Period 1, the D-W statistic still indicates no problems with autocorrelation.

Period 3 on Table 1 shows that retail prices at Stations 3 and 5 are significant determinates of daily retail prices at Station 1. As in the previous periods, the wholesale price of gasoline at Station 1 does not contribute to the retail price Station 1 charges. Relative to Period 2, the R-squared in Period 3 has increased to 85.96%. The F-statistic has also increased from the previous period to 302.34. The D-W statistic continues to indicate no autocorrelation in the model.
TABLE 1

Regression Results for $P_1^* = f(P_3^*, P_4^*, P_5^*, P_6^*, & WP_1^*)$

<table>
<thead>
<tr>
<th>Period</th>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>T</th>
<th>Significant T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>354</td>
<td>(constant)</td>
<td>-191.27344</td>
<td>-1.908</td>
<td>.0572</td>
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<tr>
<td></td>
<td></td>
<td>$P_3^*$</td>
<td>0.13998</td>
<td>4.031</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_4^*$</td>
<td>-0.17639</td>
<td>-3.875</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_5^*$</td>
<td>0.87879</td>
<td>26.345</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_6^*$</td>
<td>0.19191</td>
<td>4.437</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$WP_1^*$</td>
<td>0.02612</td>
<td>1.262</td>
<td>.2079</td>
</tr>
</tbody>
</table>

$R^2 = .95178$  \hspace{1cm} Adj. $R^2 = .95109$  \hspace{1cm} $F = 1373.90238$  \hspace{1cm} D-W = 1.89

RSS = 610,266.60288

<table>
<thead>
<tr>
<th>Period</th>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
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<th>Significant T</th>
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</thead>
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<tr>
<td>2</td>
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<td>$P_3^*$</td>
<td>0.32437</td>
<td>3.099</td>
<td>.0025</td>
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<td>$P_4^*$</td>
<td>-0.02884</td>
<td>-0.205</td>
<td>.8380</td>
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<td>$P_5^*$</td>
<td>0.33622</td>
<td>3.747</td>
<td>.0003</td>
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<td></td>
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<td>$P_6^*$</td>
<td>0.00224</td>
<td>0.017</td>
<td>.9863</td>
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<tr>
<td></td>
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<td>$WP_1^*$</td>
<td>0.22134</td>
<td>0.963</td>
<td>.3377</td>
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</table>

$R^2 = .35684$  \hspace{1cm} Adj. $R^2 = .32812$  \hspace{1cm} $F = 12.42779$  \hspace{1cm} D-W = 2.23

RSS = 1,172,680.24814

<table>
<thead>
<tr>
<th>Period</th>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>T</th>
<th>Significant T</th>
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<td>33.46956</td>
<td>0.291</td>
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<tr>
<td></td>
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<td>$P_3^*$</td>
<td>0.37633</td>
<td>5.036</td>
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<tr>
<td></td>
<td></td>
<td>$P_4^*$</td>
<td>0.07841</td>
<td>1.098</td>
<td>.2731</td>
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<tr>
<td></td>
<td></td>
<td>$P_5^*$</td>
<td>0.48437</td>
<td>7.917</td>
<td>.0000</td>
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<td></td>
<td></td>
<td>$P_6^*$</td>
<td>0.05868</td>
<td>0.886</td>
<td>.3762</td>
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<tr>
<td></td>
<td></td>
<td>$WP_1^*$</td>
<td>-0.01579</td>
<td>-0.249</td>
<td>.8036</td>
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</tbody>
</table>

$R^2 = .85956$  \hspace{1cm} Adj. $R^2 = .85671$  \hspace{1cm} $F = 302.34002$  \hspace{1cm} D-W = 2.13

RSS = 833,177.55622

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Table 2 indicates results for Station 2 which are similar to those of Station 1 represented in Table 1. In Period 1, R-Squared is .90893 while the F-statistic is significant at 720.62942. A glance at the t-statistics indicate that prices of Stations 3, 5 and 6 are significant contributors to the daily price at Station 2. The t-statistics also indicate that the daily wholesale gasoline price at Station 2 has an insignificant contribution to Station 2's daily retail price. The D-W of 2.39 is fairly high and registers as an inconclusive test on the presence of negative autocorrelation. At the 1% level of significance, with five independent variables, the inconclusive range of the D-W test begins at 2.35 and runs to 2.56. While the D-W is very close to the value which registers no autocorrelation, one must be careful in stating the reliability of the regression results.

Regression results for Period 2 on Table 2 indicate, as they did for Period 2 in Table 1, a drop in both the R-squared estimate and the F-statistic. Significant determinates on the daily retail price at Station 2 are daily prices at Stations 3 and 5. Stations 4 and 6, along with the daily wholesale price of regular at Station 2 are not statistically significant contributors to the dependent variable, Station 2's daily retail price. The D-W statistic of 2.23 is an indication of no autocorrelation.
### TABLE 2
Regression Results for $P_2^* = f (P_3^*, P_4^*, P_5^*, P_6^*, \& WP_2^*)$

<table>
<thead>
<tr>
<th>Period</th>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>T</th>
<th>Significant T</th>
</tr>
</thead>
<tbody>
<tr>
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<td>367</td>
<td>(constant)</td>
<td>-204.23058</td>
<td>-1.424</td>
<td>.1552</td>
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<tr>
<td></td>
<td></td>
<td>$P_3^*$</td>
<td>0.19222</td>
<td>4.260</td>
<td>.0000</td>
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<tr>
<td></td>
<td></td>
<td>$P_4^*$</td>
<td>-0.09081</td>
<td>-1.475</td>
<td>.1411</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_5^*$</td>
<td>0.76266</td>
<td>18.125</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_6^*$</td>
<td>0.17177</td>
<td>2.931</td>
<td>.0036</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$WP_2^*$</td>
<td>0.02861</td>
<td>0.966</td>
<td>.3349</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$r^2 = .90893$</td>
<td>Adj. $r^2 = .90767$</td>
<td>$F = 720.62942$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RSS = 1,184,169.52681</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>T</th>
<th>Significant T</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>118</td>
<td>(constant)</td>
<td>448.69428</td>
<td>1.016</td>
<td>.3117</td>
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<tr>
<td></td>
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<td>$P_3^*$</td>
<td>0.37214</td>
<td>3.498</td>
<td>.0007</td>
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<tr>
<td></td>
<td></td>
<td>$P_4^*$</td>
<td>-0.07823</td>
<td>-0.550</td>
<td>.5833</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_5^*$</td>
<td>0.32633</td>
<td>3.575</td>
<td>.0005</td>
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<td></td>
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<td>0.37214</td>
<td>0.170</td>
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<td>$WP_2^*$</td>
<td>0.26453</td>
<td>1.124</td>
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<td>$r^2 = .35215$</td>
<td>Adj. $r^2 = .32323$</td>
<td>$F = 12.17613$</td>
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<table>
<thead>
<tr>
<th>Period</th>
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<th>Variable</th>
<th>Coefficient</th>
<th>T</th>
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<td>$P_3^*$</td>
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<td>4.980</td>
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<td></td>
<td>$P_4^*$</td>
<td>0.08424</td>
<td>1.180</td>
<td>.2393</td>
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<tr>
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<td></td>
<td>$P_5^*$</td>
<td>0.49551</td>
<td>7.810</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_6^*$</td>
<td>0.06130</td>
<td>0.925</td>
<td>.3561</td>
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<td></td>
<td></td>
<td>$WP_2^*$</td>
<td>-0.04675</td>
<td>-0.618</td>
<td>.5373</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$r^2 = .85974$</td>
<td>Adj. $r^2 = .85690$</td>
<td>$F = 302.79520$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RSS = 832,100.74081</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Period 3 in Table 2 gives regression results similar to Period 3 of Table 1. The R-Squared estimate is .85956 while the F-statistic is significant by showing a value of 302.34. The D-W statistic of 2.13 indicates no autocorrelation in the model. Again, only two independent variables are significant contributors to the explanation of Station 2's daily retail price movements. These variables are, as in Period 2, daily retail prices of Stations 3 and 5. Daily wholesale price at Station 2 does not contribute to the determination of daily retail prices.

**Chow Tests**

Given regression results shown in Tables 1 and 2, it is evident that both stations exhibited very similar price relationships with other firms. The movement of R-Squared from period to period for each of the two models shown in Tables 1 and 2, are very similar for each station. Movements in F-statistics are also similar from period to period for both stations. The adjustments in t-statistics for each station over the three periods also show many similarities. In Period 1 at Station 1 variables representing competitors' retail prices are all significant. Period 1 for Station 2, however, shows only three significant variables in the determination of daily retail price at Station 2. The other regressions for following
periods indicate no differences in the number of significant variables on retail price determination at either Station 1 or Station 2. The general pattern of the residual sum of squares (RSS) is also similar for each model.

The movements in R-Squared and RSS call into question the similarity of estimated relationships from period to period. Considering Kuhlman's analysis, if the relationships among firms changed from period to period, where the delineation of periods is defined by a non-market event, the possibility of horizontal activity is increased. Through the use of Chow tests one can test if two regression estimates are different from period to period. Therefore, Chow tests are conducted and results are given in Tables 3 and 4 for Stations 1 and 2, respectively.

Table 3 shows that the regression relationships between Periods 1 and 2 changed. In other words, the relationships estimated by regression analysis for Period 1 changed in Period 2. Period 1 is also different from Period 3. The Chow test result for Periods 2 and 3 showed no significant differences in the estimated relationships among variables.

Table 4 shows results for Station 2 which match those for Station 1. Specifically, the regression estimate of Period 1 is different from the regression estimates of both Periods 2 and 3. The relationships estimated for Periods 2 and 3 show no significant difference. Therefore, the relationships among variables at Station 1 and 2 in Period 1 are different from the relationships among variables in
### TABLE 3

CHOW Test for Station 1, \( P_1^* = f(P_3^*, P_4^*, P_5^*, P_6^* \& WP_1^*) \)

\[
F^* = \frac{[Ee^{2p} - (Ee^1 + Ee^2)]/K}{(Ee^1 + Ee^2)/(n_1 + n_2 - 2(K))}
\]

#### Periods 1 & 2

- \( e_{2p}^2 = 2,030,142.04580 \)
- \( e_{21}^2 = 610,266.60288 \)
- \( e_{22}^2 = 1,172,680.24814 \)
- \( n_1 = 354 \)
- \( n_2 = 118 \)
- \( K = 6 \)

\[ F^* = 10.62938 \]

\( V_1 = 6 \)

\( V_2 = 460 \)

Critical \( F_{.01} = 2.80 \)

#### Periods 2 & 3

- \( e_{2p}^2 = 2,065,258.71614 \)
- \( e_{21}^2 = 1,172,680.24814 \)
- \( e_{22}^2 = 833,177.55622 \)
- \( n_1 = 118 \)
- \( n_2 = 253 \)
- \( K = 6 \)

\[ F^* = 1.77188 \]

\( V_1 = 6 \)

\( V_2 = 359 \)

Critical \( F_{.01} = 2.80 \)

#### Periods 1 & 3

- \( e_{2p}^2 = 1,566,299.09281 \)
- \( e_{21}^2 = 610,266.60288 \)
- \( e_{22}^2 = 833,177.55622 \)
- \( n_1 = 354 \)
- \( n_2 = 253 \)
- \( K = 6 \)

\[ F^* = 8.44036 \]

\( V_1 = 6 \)

\( V_2 = 595 \)

Critical \( F_{.01} = 2.80 \)


### TABLE 4

CHOW Tests for Station 2  \( P_2^* = f(P_3^*, P_4^*, P_5^*, P_6^* \& WP_2) \)

\[
F^* = \frac{[Ee^{2p} - (Ee^{21} + Ee^{22})] / K}{(Ee^{21} + Ee^{22}) / (n_1 + n_2 - 2(K))}
\]

**Periods 1 & 2**

<p>| | | | |</p>
<table>
<thead>
<tr>
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<th></th>
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<th></th>
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</thead>
<tbody>
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<td>0.00</td>
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<td>1,184,169.52681</td>
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</tr>
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<td>( n_1 )</td>
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</tr>
<tr>
<td>( n_2 )</td>
<td>118</td>
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<td></td>
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<tr>
<td>( K )</td>
<td>6</td>
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<td></td>
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</tbody>
</table>

\( F^* = 6.26987 \)

\( V_1 = 6 \)

\( V_2 = 473 \)

Critical \( F.01 = 2.80 \)

**Periods 2 & 3**

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<tbody>
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<td>832,100.74081</td>
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<td>( n_1 )</td>
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<td></td>
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<tr>
<td>( n_2 )</td>
<td>253</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( K )</td>
<td>6</td>
<td></td>
<td></td>
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</tbody>
</table>

\( F^* = 2.04494 \)

\( V_1 = 6 \)

\( V_2 = 359 \)

Critical \( F.01 = 2.80 \)

**Periods 1 & 3**

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<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<td>( n_1 )</td>
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<td></td>
</tr>
<tr>
<td>( n_2 )</td>
<td>253</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( K )</td>
<td>6</td>
<td></td>
<td></td>
</tr>
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</table>

\( F^* = 3.55679 \)

\( V_1 = 6 \)

\( V_2 = 608 \)

Critical \( F.01 = 2.80 \)
Periods 2 and 3. Given significant differences in the relationships among variables in Period 1 and the following periods, the analysis of covariance is conducted in the next section.

Analysis of Covariance

The alteration between Period 1 and the following periods may be a result of a shift in the constant term (i.e. Y-Intercept) or a change in the coefficients (i.e. slope) of the regression estimates. Given a change in the estimated relationships specified in the regressions of Tables 1 and 2, the alterations between periods could emanate from a change in the relationships among competitors' prices or a change in the relationships between the dependent variable and wholesale prices. According to both Cassady and Weiss, the price of gasoline, at the retail level, incorporates the wholesale price of gasoline. Both authors estimate that the wholesale price of gasoline makes up at least 75% of the retail price.\(^{(27,5,pg.395\text{ and }243\text{ respectively})}\) Therefore, retail price behavior should be a reflection of movements in wholesale prices. Given an alteration in price relationships from period to period, as indicated by Chow tests, one should expect to observe changes in the relationship of retail prices to wholesale prices. The analysis of covariance is a method which can
identify sources of variation which occur between two different estimated relationships. This is accomplished by incorporating dummy variables and interaction variables into a regression model. (22, pg. 610-21)

Equations 3, 4, 5 and 6 express the forms of the models which conduct the analysis of covariance. These models focus on the relationship of wholesale prices to retail prices over the periods studied.

(3) \( P1^* = b0 + b1(P3^*) + b2(P4^*) + b3(P5^*) + b4(P6^*) + b5(WP1^*) + b6(D2) + b7(D3) + b8(Z12) + b9(Z13) + e_i, \)

(4) \( P2^* = b0 + b1(P3^*) + b2(P4^*) + b3(P5^*) + b4(P6^*) + b5(WP2^*) + b6(D2) + b7(D3) + b8(Z22) + b9(Z23) + e_i, \)

(5) \( P1^* = b0 + b1(P3^*) + b2(P4^*) + b3(P5^*) + b4(P6^*) + b5(WP1^*) + b6(D2) + b7(D3) + e_i, \)

(6) \( P2^* = b0 + b1(P3^*) + b2(P4^*) + b3(P5^*) + b4(P6^*) + b5(WP2^*) + b6(D2) + b7(D3) + e_i. \)

Where:

\[ D2 = 1 \text{ if retail and wholesale prices are in Period 2}; \]
\[ D2 = 0 \text{ if retail and wholesale prices are in Periods 1 or 3}; \]
\[ D3 = 1 \text{ if retail and wholesale prices are in Period 3}; \]
\[ D3 = 0 \text{ if retail and wholesale prices are in Periods 1 or 2}; \]
\[ Z12 = D2 * WP1^*; \]
\[ Z13 = D3 * WP1^*; \]
\[ Z22 = D2 * WP2^*; \]
\[ Z23 = D3 * WP2^*. \]
TABLE 5

Analysis of Covariance

\[ P_1^* = f(P_3^*, P_4^*, P_5^*, P_6^*, \text{& WP}_1^*, D_2, D_3, Z_{12}, Z_{13}) \]

<table>
<thead>
<tr>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T</th>
<th>Significant T</th>
</tr>
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<tbody>
<tr>
<td>725</td>
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<td>-117.26778</td>
<td>130.05904</td>
<td>-0.902</td>
<td>0.3675</td>
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<tr>
<td></td>
<td>P_3^*</td>
<td>0.28765</td>
<td>0.03494</td>
<td>8.233</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>P_4^*</td>
<td>0.00135</td>
<td>0.04133</td>
<td>0.033</td>
<td>0.9740</td>
</tr>
<tr>
<td></td>
<td>P_5^*</td>
<td>0.60772</td>
<td>0.03156</td>
<td>19.253</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>P_6^*</td>
<td>0.12253</td>
<td>0.03745</td>
<td>3.272</td>
<td>0.0011</td>
</tr>
<tr>
<td></td>
<td>WP_1^*</td>
<td>0.01387</td>
<td>0.02896</td>
<td>0.479</td>
<td>0.6321</td>
</tr>
<tr>
<td></td>
<td>D_2</td>
<td>519.31656</td>
<td>288.89000</td>
<td>1.798</td>
<td>0.0727</td>
</tr>
<tr>
<td></td>
<td>D_3</td>
<td>177.12922</td>
<td>181.38072</td>
<td>0.977</td>
<td>0.3291</td>
</tr>
<tr>
<td></td>
<td>Z_{12}</td>
<td>-0.18802</td>
<td>0.10452</td>
<td>-1.799</td>
<td>0.0725</td>
</tr>
<tr>
<td></td>
<td>Z_{13}</td>
<td>-0.06298</td>
<td>0.06409</td>
<td>-0.983</td>
<td>0.3261</td>
</tr>
</tbody>
</table>

\[ R^2 = .92558 \quad \text{Adj. } R^2 = .92465 \quad F = 988.10497 \quad D-W = 2.11 \]

RSS = 2,877,660.30628
<table>
<thead>
<tr>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T</th>
<th>Significant T</th>
</tr>
</thead>
<tbody>
<tr>
<td>738</td>
<td>(constant)</td>
<td>-128.82168</td>
<td>146.96543</td>
<td>-0.877</td>
<td>.3810</td>
</tr>
<tr>
<td></td>
<td>P3*</td>
<td>0.30635</td>
<td>0.03674</td>
<td>8.338</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td>P4*</td>
<td>0.01908</td>
<td>0.04411</td>
<td>0.433</td>
<td>.6655</td>
</tr>
<tr>
<td></td>
<td>P5*</td>
<td>0.57475</td>
<td>0.03317</td>
<td>17.330</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td>P6*</td>
<td>0.12074</td>
<td>0.04012</td>
<td>3.009</td>
<td>.0027</td>
</tr>
<tr>
<td></td>
<td>P0*</td>
<td>0.12074</td>
<td>0.04012</td>
<td>3.009</td>
<td>.0027</td>
</tr>
<tr>
<td></td>
<td>WP0*</td>
<td>0.01634</td>
<td>0.03259</td>
<td>0.501</td>
<td>.6163</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>552.70420</td>
<td>319.83018</td>
<td>1.728</td>
<td>.0844</td>
</tr>
<tr>
<td></td>
<td>D3</td>
<td>234.21119</td>
<td>215.56057</td>
<td>1.087</td>
<td>.2776</td>
</tr>
<tr>
<td></td>
<td>Z22</td>
<td>-0.20049</td>
<td>0.11568</td>
<td>-1.733</td>
<td>.0835</td>
</tr>
<tr>
<td></td>
<td>Z23</td>
<td>-0.08236</td>
<td>0.07599</td>
<td>-1.084</td>
<td>.2788</td>
</tr>
</tbody>
</table>

$R^2 = .91235$  $\text{Adj. } R^2 = .91127$  $F = 842.02093$  $D-W = 2.23$

$RSS = 3,419,168.72921$
Equations (3) and (4) check for changes in the coefficient on wholesale prices over the entire 810 day period. Equations (5) and (6) check for shifts in the constant term. If, in equations (3) and (4), the interaction variables (Z12, Z13, Z22 and Z23) are significant, the differences identified by the Chow tests are attributed to changes in the coefficients on wholesale price. If, in equations (5) or (6), the coefficients on D2 or D3 are significant, the differences identified by the Chow tests are attributed to changes in the constant term. The results of equations (3), (4), (5), and (6) are in Tables 5, 6, 7, and 8 respectively.

Table 5 indicates that the interaction variables of equation (3) are insignificant. This implies that there is not enough variation in the equation to register a change in the coefficient on wholesale price, WP1. The overall regression is significant as indicated by an F-statistic of 988.10497. The R-Squared is .92558 and there is no indication of autocorrelation. As in previous regression results, daily wholesale price is an insignificant contributor to the daily retail price of gasoline at Station 1.

Table 6 shows results of equation (4). These results, like those for equation (3), indicate that there is not enough variation in the estimated relationship to register an alteration in the coefficient on wholesale price at Station 2, WP2. As with equation (3), equation (4) has a
TABLE 7

Analysis of Covariance Cont'd

\[ P_1^* = f(P_3^*, P_4^*, P_5^*, P_6^*, & WP_1^*, D2, D3) \]

<table>
<thead>
<tr>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T</th>
<th>Significant T</th>
</tr>
</thead>
<tbody>
<tr>
<td>725</td>
<td>(constant)</td>
<td>19.97004</td>
<td>80.63558</td>
<td>0.248</td>
<td>.8045</td>
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<tr>
<td></td>
<td>P_3^*</td>
<td>0.28794</td>
<td>0.03473</td>
<td>8.292</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td>P_4^*</td>
<td>-0.01104</td>
<td>0.04080</td>
<td>-0.271</td>
<td>.7868</td>
</tr>
<tr>
<td></td>
<td>P_5^*</td>
<td>0.59949</td>
<td>0.03112</td>
<td>19.267</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td>P_6^*</td>
<td>0.12249</td>
<td>0.03744</td>
<td>3.271</td>
<td>.0011</td>
</tr>
<tr>
<td></td>
<td>WP_1^*</td>
<td>-0.01422</td>
<td>0.02022</td>
<td>-0.703</td>
<td>.4822</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>0.22170</td>
<td>7.61689</td>
<td>0.029</td>
<td>.9768</td>
</tr>
<tr>
<td></td>
<td>D3</td>
<td>3.62634</td>
<td>10.16979</td>
<td>0.357</td>
<td>.7215</td>
</tr>
</tbody>
</table>

\[ R^2 = .92523 \quad \text{Adj. } R^2 = .92450 \quad F = 1267.44732 \quad \text{D-W} = 2.10 \]

\[ \text{RSS} = 2,891,371.35575 \]

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TABLE 8

Analysis of Covariance Con't

\[ \begin{align*}
P_2^* &= f(p_3^*, p_4^*, p_5^*, p_6^*, \& w_2^*, d_2, d_3) 
\end{align*} \]

<table>
<thead>
<tr>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T</th>
<th>Significant T</th>
</tr>
</thead>
<tbody>
<tr>
<td>738</td>
<td>(constant)</td>
<td>35.45550</td>
<td>89.88897</td>
<td>0.394</td>
<td>.6934</td>
</tr>
<tr>
<td></td>
<td>p_3^*</td>
<td>0.30541</td>
<td>0.03649</td>
<td>8.368</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td>p_4^*</td>
<td>0.00599</td>
<td>0.04355</td>
<td>0.137</td>
<td>.8907</td>
</tr>
<tr>
<td></td>
<td>p_5^*</td>
<td>0.56461</td>
<td>0.03251</td>
<td>17.366</td>
<td>.0000</td>
</tr>
<tr>
<td></td>
<td>p_6^*</td>
<td>0.12046</td>
<td>0.04355</td>
<td>3.005</td>
<td>.0027</td>
</tr>
<tr>
<td></td>
<td>w_2^*</td>
<td>-0.01718</td>
<td>0.02265</td>
<td>-0.759</td>
<td>.4484</td>
</tr>
<tr>
<td></td>
<td>d_2</td>
<td>-0.87612</td>
<td>8.20755</td>
<td>-0.107</td>
<td>.9150</td>
</tr>
<tr>
<td></td>
<td>d_3</td>
<td>5.60083</td>
<td>11.19408</td>
<td>0.500</td>
<td>.6170</td>
</tr>
</tbody>
</table>

\[ R^2 = .91196 \quad \text{Adj. } R^2 = .91112 \quad F = 1080.23578 \quad D-W = 2.22 \]

\[ \text{RSS} = 3,434,573.40168 \]
good R-Squared and a significant F-statistic. The D-W statistic, at 2.23, gives an indication that autocorrelation is not present. The daily wholesale price of gasoline has no significant effect on the daily retail price of gasoline at Station 2.

Table 7 presents results for equation (5). Equation (5) tests for a shift in the constant term over three periods at Station 1. The t-statistics on D2 and D3 are insignificant; therefore, one cannot infer that the estimated relationship shifted over the periods studied. The F-statistic is equal to 1267.44732 while R-Squared is .92523. The D-W statistic of 2.09630 indicates no autocorrelation in the model.

Table 8 indicates results for Station 2 which are very similar to those expressed in Table 7. First, the t-statistics on D2 and D3 are insignificant. Therefore, no shift in the constant term is evident. Second, the F-statistic is significant at a value of 1080.23578. The estimate on R-Squared is also similar to that for equation (5). In equation (6) R-Squared is equal to .91196. The D-W statistic is equal to 2.22 thus indicating no autocorrelation. As in previous models, the daily wholesale price of gasoline is a statistically insignificant determinate on daily retail price at Station 2.

Wholesale Price Stability
Given the results of Chow tests and the analysis of covariance, an analysis of wholesale prices over time is used to generate possible corroborating evidence to the stability of wholesale prices. The analysis of covariance indicates that wholesale prices did not contribute to the alterations identified by Chow tests. Therefore, one more regression procedure may produce confirmation of the fact that price adjustments at Stations 1 and 2 do not reflect movements in wholesale prices from Period 1 to Period 2.

Equations (7) and (8), given below, incorporate dummy variables to check for a shift in wholesale prices from Period 1 to Period 2.

\[
(7) \quad WP_1 = b_0 + b_1(T) + b_2(T \text{ Squared}) + b_3(D.V.) + e_i, \\
(8) \quad WP_2 = b_0 + b_1(T) + b_2(T \text{ Squared}) + b_3(D.V.) + e_i. 
\]

Where:

- \( T \) = Integer value of each day from 12/01/77 to 7/15/78;
- \( T \text{ Squared} \) = Squared value of integer days from 12/01/78 to 7/15/78;
- \( D.V. = 1 \) if observation is after March 20, 1978;
- \( D.V. = 0 \) if observation is before March 21, 1978.

The period of 12/01/77 to 7/15/78 consists of 222 days where
the midpoint is March 20, 1978, two days after the publication of The Missoulian's article and the first day of Period 2. The results of equations (7) and (8) are in Tables 9 and 10 for Stations 1 and 2 respectively. T-Squared is put into the equation to discover if wholesale price movements demonstrate a curvilinear pattern.

By observing the t-statistics in Table 9, one can see that the wholesale price function at Station 1 (i.e. equation 7), does not shift over the period of December, 1977 to July, 1978. It is evident that there is a slightly positive curvilinear relationship of wholesale prices and time. R-Squared is .67624 while the F-statistic is 148.994. The D-W statistic is 2.107, indicating no autocorrelation.

Table 10 indicates results for Station 2 (i.e. equation 8). The t-statistic on the dummy variable is insignificant, indicating no shift in the wholesale price pattern. The R-Squared is 62% while the F-statistic is significant at 117.201. The D-W statistic of 1.98 indicates no autocorrelation is present in the model.

Given the results shown in Tables 9 and 10, it is apparent that the findings on wholesale price in the analysis of covariance are corroborated. There is no shift in the wholesale price pattern which can explain the differences in retail price behavior identified by Chow tests.
<table>
<thead>
<tr>
<th>N of Cases</th>
<th>Variable</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T</th>
<th>Significant T</th>
</tr>
</thead>
<tbody>
<tr>
<td>218</td>
<td>(constant)</td>
<td>1185.25893</td>
<td>41.78544</td>
<td>28.365</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>( T )</td>
<td>-14.67227</td>
<td>1.27660</td>
<td>11.493</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>( T^2 )</td>
<td>0.01790</td>
<td>0.00140</td>
<td>12.740</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>( D1 )</td>
<td>-1.93684</td>
<td>2.99269</td>
<td>0.647</td>
<td>0.5182</td>
</tr>
</tbody>
</table>

\( R^2 = 0.57624 \) \( \text{Adj. } R^2 = 0.67170 \) \( F = 148.99399 \) \( D-W = 2.11 \)

\( RSS = 26,520.63324 \)
### TABLE 10

Regression Results on WP₂⁺, = f(T, T² & D2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>T</th>
<th>Significant</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>954.05441</td>
<td>38.82504</td>
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<td></td>
</tr>
<tr>
<td>T</td>
<td>-14.51641</td>
<td>1.46454</td>
<td>-9.912</td>
<td>.0000</td>
<td></td>
</tr>
<tr>
<td>T²</td>
<td>0.01763</td>
<td>0.00161</td>
<td>10.982</td>
<td>.0000</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>-0.43066</td>
<td>2.75932</td>
<td>-0.156</td>
<td>.8761</td>
<td></td>
</tr>
</tbody>
</table>

R² = .62164  Adj. R² = .61634  F = 117.20052  D-W = 1.98  
RSS = 22,547.31515
Margin Analysis

The selling price in any retailing business usually is made up of the cost of goods sold and a gross margin. If the gross margin is greater than the operating expenses of retail business, the remainder is referred to as a net margin. (27, pg. 394) Given high elasticity of demand, high margins do not necessarily translate into high profits. In some instances, a retailer can increase total profit by decreasing the retail price and selling a greater volume. (27, pg. 395) In some case, high margins are indicative of more expensive service. However, Weiss goes on to say that "In some instances, as we shall see, high margins may also reflect monopoly restrictions." (27, pg. 395) Typically, when competitive pressures increase, such as in a price war, retail prices will drop thus placing a "squeeze" on the gross margin. One can assess competitive behavior by analyzing gross margins. Given elastic demand at a particular station, when competition is keen, the margins will be low. When competitive pressure is not intense, margins will be high.

Tables 11 and 12 show the actual average monthly margin for Stations 1 and 2, respectively. They also indicate an estimate of the yearly average for both years at both stations. Figure 1 is a graphical representation of the data in Tables 11 and 12. In Figure 1 one can see interesting movements. There appears to be a seasonal trend in the movement of average monthly margins. Margins are
## TABLE 11

### Station 1

<table>
<thead>
<tr>
<th>Month</th>
<th>Margin '77</th>
<th>Average Margin '77</th>
<th>Margin '78</th>
<th>Average Margin '78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>7.53</td>
<td>$X'77 = 5.932$</td>
<td>4.58</td>
<td>$X'78 = 4.585$</td>
</tr>
<tr>
<td>Feb</td>
<td>5.42</td>
<td>5.35</td>
<td>5.35</td>
<td></td>
</tr>
<tr>
<td>Mar</td>
<td>5.38</td>
<td>3.45</td>
<td>3.39</td>
<td></td>
</tr>
<tr>
<td>Apr</td>
<td>5.36</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>3.59</td>
<td>2.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun</td>
<td>4.64</td>
<td>2.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>4.62</td>
<td>5.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>8.10</td>
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<td>6.69</td>
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<tr>
<td>Sep</td>
<td>8.47</td>
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<td>7.70</td>
<td></td>
</tr>
<tr>
<td>Oct</td>
<td>7.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov</td>
<td>6.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec</td>
<td>4.81</td>
<td></td>
<td>6.77</td>
<td></td>
</tr>
</tbody>
</table>

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### TABLE 12

Station 2

<table>
<thead>
<tr>
<th>Month</th>
<th>Average Margin '77</th>
<th>Average Margin '78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>$6.98</td>
<td>$4.98</td>
</tr>
<tr>
<td>Feb</td>
<td>4.56</td>
<td>5.87</td>
</tr>
<tr>
<td>Mar</td>
<td>4.65</td>
<td>3.74</td>
</tr>
<tr>
<td>Apr</td>
<td>6.02</td>
<td>3.25</td>
</tr>
<tr>
<td>May</td>
<td>5.08</td>
<td>3.15</td>
</tr>
<tr>
<td>Jun</td>
<td>4.34</td>
<td>3.64</td>
</tr>
<tr>
<td>July</td>
<td>4.56</td>
<td>3.46</td>
</tr>
<tr>
<td>Aug</td>
<td>6.91</td>
<td>4.82</td>
</tr>
<tr>
<td>Sep</td>
<td>7.98</td>
<td>3.55</td>
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<tr>
<td>Oct</td>
<td>7.34</td>
<td>7.00</td>
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<tr>
<td>Nov</td>
<td>5.79</td>
<td>6.65</td>
</tr>
<tr>
<td>Dec</td>
<td>4.89</td>
<td>7.38</td>
</tr>
</tbody>
</table>

$\bar{x}'77 = 5.591$  \hspace{1cm} $\bar{x}'78 = 4.790$
highest during winter months, when consumers are reluctant to brave icy roads. Thus, demand is low and so is the competitive pressure felt by gasoline dealers. As warm weather approaches during spring months, driving increases and margins decrease. Specifically, one can see a drop in the gross margin from March 1977 to May 1977 for both stations. From May to September of 1977 the monthly margins at both stations show a steady rise. In 1978, the year which includes Period 2, monthly margins for Station 1 dropped from February to June. From June to August, Station 1 shows a continual increase in its gross margins. The lowest margin for either station is recorded in June of 1978 at Station 1. June of 1978 is included in Period 2 of the regression analysis. While monthly margins declined in the first half of both years, the decline in 1978 is longer and more drastic than the decline in the first half of 1977. For Station 1, the margin of June, 1978 is 2.49 cents per gallon. The margins in 1978 at each station reach the 7 cents per gallon range but never regain the levels of 1977. A glance at Table 11 indicates that the yearly average margin in 1977 is about 1.5 cents per gallon higher than in 1978. Table 12 shows that for Station 2, the 1977 average yearly margin is slightly under a penny more than the average yearly margin in 1978.

The average monthly margins indicate that in 1978 the margins are lower than in 1977. The monthly margins reached a minimum in June of 1978 at Station 1. The movements in
monthly margins from March of 1978 to July of that same year indicate generally lower margins than in the same period of the previous year. These results indicate that competitive pressures increased at both stations in 1978 relative to 1977. Moreover, since the monthly margins reached an overall minimum in June of 1978, which is included in Period 2, one can speculate that the article in *The Missoulian* had an effect on the competitive behavior of Stations 1 and 2. This effect is one which increased competition and therefore lends credibility to an inference of collusion on the part of the five gasoline firms studied in this thesis.
CHAPTER FIVE

Introduction

This last chapter discusses three issues. First, a presentation of the conclusions produced by this thesis. Second, a discussion of policy recommendations which speak to the use of statistical techniques in assessing the possibility of horizontal pricing agreements. Last, a presentation of the model's limitations and problems.

Conclusions

Empirical investigation produces three significant results. First, and perhaps most important, wholesale prices of gasoline are not statistically significant contributors to the determination of daily retail price at Stations 1 and 2. Second, Chow tests indicate that regressions of Period 1 differ from regressions in either Period 2 or Period 3. This implies that the relationships found in Period 1 changed relative to the relationships found in Periods 2 or 3. Given that the beginning of Period 2 closely coincides with the publication of The Missoulian's article, a non-market event, John Kuhlman's procedure

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suggests that differences identified by Chow tests indicate possible collusive behavior in the retail gasoline market. Third, empirical results from the analysis of covariance indicate that the differences identified by Chow tests are not attributed to changes in either the coefficient on wholesale price or a change in the constant term. Given the results of covariance procedure, one can only conclude that alterations between periods emanate from alterations in the relationships between competitors' retail prices. This finding is substantiated by the regressions which check the stability of wholesale prices over time. These regressions indicate that the pattern of wholesale prices did not shift when the retail prices did indeed show alterations in regression relationships. This analysis confirms the earlier work conducted by Dr. O'Donnell and improves the model's specificity in the wholesale price analysis.

The analysis of average monthly margins indicates that in Period 2, the margins at Stations 1 and 2 are at their lowest levels. The overall average yearly margin is lower in 1978 than in the previous year. Moreover, the movements in March, April, May and June of 1977 do not drop to as low a point as they do in the same months of 1978. Therefore, given assertions advanced by both Weiss and Cassady, competitive pressures in 1978 are greater than those in 1977.
Given the above results, this thesis concludes that the observed alterations in retail price patterns of Stations 1 and 2 have no relationship to the pattern of wholesale prices. Moreover, it is seen that retail prices at competing stations have a highly significant effect on the determination of retail prices at Stations 1 and 2. While it is normal to have competitors' prices influence pricing at a particular station, it is unusual that wholesale prices have no effect.

One might try to conclude that Station 1 and 2 are merely acting as price takers and that the price they offer is set by the equilibrium conditions of perfectly competitive markets. Given this argument, Period 2 is a period of disequilibrium which could occur from disruptions in supply, entry or exit, cost movements or demand fluctuations. However, none of these disruptions are evident in the study periods. Therefore, the disruptions noticed in Period 2 may very well have no association to measurable market influences. The possibility of collusion is thus increased.

Policy Recommendations

Utilizing an analysis based on price tracking can be an unquestionable aide in determining the competitive behavior of a market. However, results generated by this analysis
may be difficult to understand in most forums of inquiry. Therefore, the most beneficial use of this technique is in the area of research on industries or markets especially prone to horizontal agreements. Research such as this would probably aid in saving downstream costs of litigation.

**Limitations of Methodology**

The first limitation one encounters with this model lies with the data requirements. The data needed is usually confidential and can only be received by court order. Second, one should have a firm understanding of market structure before attempting this analysis. Price matching is not necessarily an indication of misdeeds and in some markets is accepted as the normal price behavior. Therefore, without an understanding of a market structure's price behavior, incorrect inference is very likely.
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