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AN EMPIRICAL STUDY OF SELECTED CAUSES AND EFFECTS OF SEMIRIGID PRICES IN THE PETROLEUM REFINING INDUSTRY WITH EMPHASIS ON THE PERIOD 1963 THROUGH 1972

AN EMPIRICAL STUDY OF SELECTED CAUSES AND EFFECTS OF SEMIRIGID PRICES IN THE PETROLEUM REFINING INDUSTRY WITH EMPHASIS ON THE PERIOD 1963 THROUGH 1972

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

By

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1975
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ACKNOWLEDGEMENTS

My original interest in this limited investigation of the pricing structure of the petroleum refining industry was occasioned by a newspaper headline several years ago which proclaimed a shortage of residual fuel oil. After contacting acquaintances within the industry, I learned there was only a domestic shortage of residual fuel oil at the existing price. The fact that there appeared to be fairly rigid external policies affecting industry prices caused me concern regarding the effect of these rigidities on accounting methods and investment decisions.

Dr. Nolan Williams must be given credit for directing my thought processes toward the difficulty of the task by asking a series of crucial questions during the formative stages of the study. Without his assistance and constructive criticism the real focus of the problem might have been lost.

Special recognition should also be given to Mr. Lynn M. Nichols, a former editor of the Oil and Gas Journal for his assistance early in the study. Mr. Nichols also arranged an introduction to Dr. W. L. Nelson who contributed of his valuable time as consultant to the industry, professor, and technical editor for the Oil and Gas Journal to brief me on the complexities of the competitive forces within the industry. In addition, both Mr. Nichols and Mr. David Ringer exhibited great patience in reading and interacting on the text of the study during the writing process.

A significant contribution was also made by each of the companies that cooperated in this study. Special thanks are due each executive who gave so willingly of his valuable time. Without each individual's cooperation and the motivation and typing assistance received from my wife this study would not have been possible.

Robert Eugene Feller

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Chapter 1

INTRODUCTION

Many recently developed decision tools are being used in the petroleum refining industry. Specifically, the industry's major firms have competent staffs studying alternate applications of quantitative techniques. The entire refining operations of some of these firms have been simulated with computer models. The mathematical models thus developed predict the output of each of a large number of different types of refining processes with practical accuracy. The actual outputs of the refinery units can now be changed by reprocessing to produce the end products desired by management. This recycling creates a flexibility within the refinery unit. The refining operation has therefore become more of a manufacturing (as compared to a processing) activity than heretofore envisioned by the general public. A discussion of this new "manufacturing" characteristic of the refining industry was included in a dissertation entitled "Accounting and Management Control Practices in Petroleum Refining."[1]

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[1]William F. Schmeltz, "Accounting and Management Control Practices in Petroleum Refining" (unpublished Doctor's dissertation, Western Reserve University, 1966) Distributed by Standard Oil Co. of Ohio.

The study of refinery-related problems was made more complex, therefore, for at least two reasons. Improvements in refining technology have allowed an expansion of refinery products where an intricate joint production problem already existed. In addition, the magnitude of the production alternatives in modern refineries has made the application of computer simulations and quantitative techniques advantageous for total revenue total cost studies. These simulations have added their own complexities.

THE PROBLEM

Joint cost allocation has remained an "insolvable" problem with respect to an exacting, accurate, and defensible solution. Many solutions have been proposed and carefully studied; however, not one has proved invulnerable to all valid logic. The most practical and theoretically sound method advanced by accountants was the generally accepted allocation of joint cost based upon the relative market value of the products. Implicit in this theory was the assumption that prices of the various products are flexible and represent an interaction of supply and demand.

Some authors of accounting principles textbooks have suggested the price-relative solution to joint cost allocations as the best method available. These authors usually list refining, meat processing, and real-estate division as appropriate applications of this method. Simultaneously, authors of management accounting textbooks have emphatically stated that joint cost allocations were inappropriate for decision making purposes. The primary reason given was the arbitrary selection of relative prices as the cost allocator. The net result of the difference of opinion has been the use of the price-relative method for inventory purposes and the use of no allocation at all for managerial decision making purposes.

There is evidence that cost allocations have long been questioned by operating personnel as shown by the following quotation: "I also have generally concluded from reviewing the literature that refinery managers tend to view all calculated refinery cost with suspicion."[2] This doubt coupled with the newer characteristics of modern refineries suggests the following questions:

1. Was the price-relative joint-cost-allocation method included in the decision models used to determine new internal refinery investment?

2. If the traditional joint-cost-allocation method was appropriate, how could accountants obtain more acceptance for this method in the decision model?

3. If traditional joint cost allocation was not appropriate, was a study then necessary to determine more appropriate input into the decision model?

The possibility of semirigid prices for petroleum products adds an additional complexity to the problem. If prices are found to be semirigid and costs are related to prices, then costs are also semirigid. This possibility

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[2]Ibid,. p. 105.

suggests several additional questions such as:

1. Are supply and demand interactions the <u>exclusive</u> determinants of refined-product prices during the period under study?

2. Are artificial price rigidities in evidence?

3. Do accounting techniques or economic interpretations contribute to the price rigidities?

4. Are joint cost allocations based upon relative market values as undesirable as suggested in management accounting literature?

5. What effects do price rigidities have on the price-relative joint-cost allocation?

6. What effects do price rigidities have on refinery investment decisions?

Statement

The multifaceted purpose of this study is to investigate activities and policies which appeared to create artificial restraints on prices from 1963 to 1972, to determine the effect of rigidities in price on refinery investment decisions, and to consider the accounting and economic implications of price rigidities.

Another possibility is also explored in this study. The implicit assumption of price flexibility necessary for the price-relative joint-cost allocator to have managerial significance may not have been possible in the petroleum-refining industry during the period under observation due to artificial or external constraints on price.

Importance

Regardless of the method used to decide among investment alternatives when allocating resources within any particular organization, both the expected revenue and the attendant costs from a potential investment must be estimated. The prominent methods deal with the difference between the total revenue flow and the cash costs of that flow. Some reasonably accurate approximation of this difference is required whether the method be discounted cash flow, years to pay out, or return on investment.

Refinery investment decisions are more complex than most other decisions but they are not basically different. The decision to build a completely new facility is usually determined by the total projected revenue less total projected cost; however, the product mix is a much more difficult forecast. Without a reliable indicator of individual product cost there is no accurate way to determine the excess of projected revenue over projected cost for each product.

A Lead Indicator of Change

In the past, technological progress was slower and the dollar investment in refineries was smaller. Under these conditions, the potential distortion of the investment decisions affecting the component parts of the refinery was not so critical because alternative processing techniques were not available. Mistakes were corrected by time without severe repercussions.

During the last century a major but gradual transition in refinery output from kerosine to high-octane gasoline has occurred without extreme financial disaster. If a major technological breakthrough or severe environmental restriction were suddenly to occur, the industry would be dealt a severe financial blow. The potential loss would be millions of dollars of investment due to obsolescence. A reasonably gradual change in demand among the various products could be met with minimal loss if some indicator in the investment model were to change. This change would denote the need for a shift in investment within the refinery. If prices were semirigid and traditional accounting methods were followed, it is doubtful that any such indicator would be present in the investment model. New refinery investment would be continuously allocated on the old basis until an emergency was reached.

Shortage of Capacity

A national shortage of refinery capacity became apparent to informed observers in 1973. Many people only recognized a gasoline shortage and were unaware of the refinery-capacity problem. With most of the petroleum industry's major firms possessing competent staffs, well trained in the latest quantitative techniques, this fact seems to require an explanation. The first conclusion one might reach is that the oligopoly structure has acted to artificially limit available products and raise the price structure.

Additional facts must be considered. Alleged shortages of fuel oil and alleged overproduction of higher-octane products have occurred within the same year. Prices of higher-octane products have long been depressed even while petroleum resources were dwindling as attested by a constant reduction of proven domestic reserves. This more complete picture of the situation in the petroleum refining industry may seem a strange paradox to even the casual observer. If petroleum resources were scarce in the long run, then the price of petroleum products should have demonstrated a long-term upward trend under normal circumstances.

There was no "absolute" shortage of fuel oil, but there was a domestic shortage of fuel oil at the existing low prices. Facts have been presented in Chapter 4 which lead to the conclusion that forces other than supply and demand for petroleum products in the United States were operating to establish prices. One should not necessarily infer from this statement that a conspiracy existed or that the price policies established by a few firms were the exclusive determinants of price within the industry. However, if only free-market forces were at work, one would have expected the fuel-oil price to rise and the gasoline price to lower until the increased fuel-oil price attracted some of the surplus refinery capacity devoted to higher-octane fuels. Both prices would then tend toward a higher long-run price expectation.

Wasted Resources

Given the existing circumstances, one might expect to see a waste of natural resources. The best investment indicators continue to induce an oversupply of higher-octane products because of analytical methods to be discussed later. This temporary oversupply was reflected in the depressed gasoline prices which may have induced marginal consumers to purchase additional products. One would expect most gasoline consumers to behave in a manner similar to that explained in Duesenberry's relative-income hypothesis.[3]

There is, however, another facet to the problem. If price-relative joint cost allocations are inappropriate and this fact is recognized by operating personnel before it is recognized by the accounting profession, operating personnel may (in an attempt to improve input into their investment model) experiment with other cost allocators more detrimental to the investment model's output than the traditional price-relative joint cost allocation. In the intricacies of today's complex quantitative models some decisions could be reached and seemingly justified. However, if these decisions were studied in a less-complex setting, or from a more-theoretical point of view, they might prove unacceptable.

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[3]James S. Duesenberry, "Income-Consumption Relations and Their Implications," an essay in Income, Employment and Public Policy, ed. Lloyd A. Metzler (New York: W. W. Norton & Co., Inc., 1948), pp. 54-81.

THE APPROACH OF THIS EVALUATION

Methodology

A careful review was made of the accounting literature to determine whether this problem had been previously investigated. After finding no such research, a pilot study was conducted at a medium-sized oil company to determine the best approach to the problem. This pilot project and an accounting-literature review suggested some of the problems associated with rigid prices.

The investigation necessarily encompassed some sensitive data in pricing and price expectations. The anticipated reluctance of company executives to provide this kind of information almost proved to be a serious barrier to the study. However, other data dependent upon, but not revealing price structure, were obtained. General statements concerning price expectations when coupled with post-completion audit evaluations provided sufficient verifiable evidence to proceed with the study without current detailed price figures.

Two primary research methods involving empirical data have been used. Because of the confidential nature of much of the information, personal interviews were sought with a significant portion of the firms responsible for United States refinery-investment decisions. In the larger oil companies those individuals contacted were usually located in a forward-planning division or in an economic group responsible for forward planning. The interviews were unstructured to allow participants to speak more freely about potentially confidential material. An attempt was made to obtain information from a significant portion of the firms and to examine a few older investment decisions (either conducting a postcompletion audit evaluation or examining the results of one) on each of three decision size levels - small, medium and large.

Because of the confidential nature of much of the material, no firm has been identified although trends have been revealed. The firms, if referred to, were given fictitious names. In addition to the empirical evidence obtained from the firms contacted, considerable empirical data concerning the oil industry as a whole were available from several published sources and these data have been included in the study where appropriate.

Organization of the Evaluation

The evaluation of traditional joint cost accounting as it relates to internal investment decisions within the petroleum-refining industry has been described in detail under the following headings:

Chapter 2: Cost Accounting Within the Refinery Segment of the Petroleum Industry. The historic development and theoretical justification of joint cost accounting methods are presented to provide a background for the analysis. Special emphasis is placed upon methodology in joint costing and the implicit assumptions of different methods. In addition, the manufacturing, as opposed to processing, characteristics of the refining industry have been examined. Current practices in the industry have been reviewed, and available existing research on costing practices has been analyzed.

Chapter 3: Prices In the Petroleum Industry. Economic theory underlying the industry's pricing was briefly reviewed and compared to current practices. Observations on why oligopoly pricing might not have been possible in the petroleum industry during the period under study are presented.

Chapter 4: Factors Affecting Price Flexibility of Joint Products in the Refinery Segment of the Petroleum Industry. Regulatory agencies and congressional actions have a definite effect on price flexibility in certain portions of the joint product mix. Another influence has been the unusual competition monopolies exerted upon areas of the product mix. The United States crude oil import program and related defense considerations definitely affected pricing within the industry and have been considered. In addition, one of the most currently volatile subjects, the impact of ecological factors, has been considered together with some effects of policy fixation (the reluctance to change a proven policy despite changing conditions).

Chapter 5: Decision Processes Examined. The extent to which traditional joint cost accounting was used in the investment decision process has been briefly examined. The results of selected postcompletion audits of refinery investment decisions have been summarized. Interviews have been conducted with the management of a significant portion of total refinery capacity in existence on January 1, 1973.

Chapter 6: Summary and Conclusions: The foundational materials and the empirical research developed and presented in prior chapters have been reviewed and analyzed. The conclusions and opinions reached as a result of this analysis have been presented together with recommendations either for action to be taken or further research to be considered.

Chapter 2

COST ACCOUNTING WITHIN THE REFINING SEGMENT OF THE PETROLEUM INDUSTRY

INTRODUCTION

Accounting literature contains few references in which the theoretical alternatives available for the allocation of joint-production costs are examined. According to John Dearden, "Joint production occurs whenever two or more products must result from the same production process."[1] When the choice of products to be produced is assumed to be fixed in the short run, the traditional price-relative accounting approach to the problem of joint-cost allocation appears logical. Although this assumption of fixed short-run production options seems to permeate the accounting literature available, it is not often specifically stated.

General accounting aspects of joint cost allocations are reviewed in this chapter. In addition, specific problems associated with the petroleum-refining industry are considered. Since in-depth coverage of joint-production-

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[1]John Dearden, Cost and Budget Analysis (New Jersey: Prentice Hall, Inc., 1962), p. 46.

cost allocation in accounting literature is so scarce, the following framework will be followed:

1. The early development of joint cost allocations
2. Cautions against and modifications to price-relative joint production cost allocations suggested in the literature
3. The manufacturing nature of refining
4. Current accounting practices in the industry
5. The quandary in the application of theory
6. Existing research on costing practices
7. A more precise statement of the current problem.

This review of the available accounting literature on joint-production-cost allocation should provide needed background for the material to be presented in later chapters, while the attempts of authors to modify and caution against the generally accepted treatment should emphasize the difficulty of the subject.

THE EARLY DEVELOPMENT OF JOINT COST ALLOCATIONS

Early accountants were so occupied with recording and verifying data that little study was devoted to new areas of managerial assistance. Cost accounting procedures were first widely publicized around the turn of this century. The first published study of costs as a separate topic in the United States was by Henry Metcalf, an Army Ordnance captain. In 1885 he wrote "Cost of Manufactures," and thus broke a period of silence.[2] Silence existed because cost accounting had long been considered confidential. Costs were used almost exclusively to establish price and any disclosure of cost disclosed price. Since the Army was not competing with other manufacturers, cost disclosures did not offer a competitive advantage that would cause concern.

Apparently few early writers even considered the subject of joint production cost allocation. As an example, Alexander Hamilton Church, a recognized cost authority who was particularly interested in overhead allocations, devoted only a small portion of his writing to by-product accounting.[3] His observations on this phase of accounting were thorough, but did not embrace true joint-production-cost allocation. Church recommended that by-products either be credited at the sales price, less cost of recovery in the manufacturing account, or that the original cost be divided on the basis of the relative weight of the by-products to the main products, if these figures were available.

A specific time for the introduction of the price-relative approach to the solution of the joint-cost-allocation problem was not readily apparent. The approach

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[2]Captain Henry Metcalf, The Cost of Manufactures (New York: John Wiley & Sons, 1885).

[3]A. Hamilton Church, Manufacturing Costs and Accounts (New York: McGraw-Hill Book Company, 1929), p. 106.

was mentioned as early as 1903 by Stanley Garry.[4] Establishing this time does not appear essential to the discussion since more recent accounting principles authors have traditionally described the price-relative approach with little if any discussion of potential problems or alternate views. For example, Pyle and White state in their sixth edition of Fundamental Accounting Principles,

> A joint cost may be, but is not commonly, allocated on some physical basis. ... The usual method of allocating a joint cost is in the ratio of the market values of the joint products at the point of separation.[5]

Niswonger and Fess in their eleventh edition of Accounting Principles mention only one allocation method, "the market (sales) value method."[6]

A study of the persons involved with cost concerns during the early period provides the basis for a logical observation. They were not accountants, but rather managers, consultants, and engineers. Their real concern was with efficiency, but efficiency was hard to measure objectively and report on successfully. As one engineer stated it:

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[4]H. Stanley Garry, "Factory Costs," The Accountant, (July 25, 1903), pp. 955-7.

[5]William W. Pyle and John Arch White, Fundamental Accounting Principles (6th ed.; Homewood, Illinois: Richard D. Irwin Inc., 1972), p. 606.

[6]C. Rollin Niswonger and Philip E. Fess, Accounting Principles (11th ed.: Cincinnati, Ohio: South-Western Publishing Company, 1973), p. 521.

> ... one of the tasks of modern scientific management, ... is to convert efficiency records into cost records since the language of cost is understood by all, the language of efficiency only by a few.[7]

The method advocated almost exclusively by current accounting principles textbook writers has not changed appreciably from that method introduced by earlier writers. This method (price-relative) allocates the cost of a joint product by multiplying the total cost by a different fraction for each of the component products produced. Each fraction is determined by placing the market value of the individual product to be costed in the numerator and the total market value of all products produced in the denominator. Although the selection of this method has been labeled arbitrary by most management accounting writers, it remains the most widely accepted accounting method.

CAUTIONS AGAINST AND SUGGESTED MODIFICATIONS TO PRICE-RELATIVE JOINT-PRODUCTION-COST ALLOCATION

Harold G. Avery and numerous other authors in management-accounting textbooks have cautioned against the arbitrary nature of the price-relative approach.[8] Their criticism is well phrased by John Dearden, "... all cost

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[7]Harrington Emerson, The Twelve Principles of Efficiency (New York: The Engineering Magazine, 1913), p. 215.

[8]Harold G. Avery, "Accounting for Joint Costs," The Accounting Review, XXVI (April, 1951), 232.

allocations among joint products are entirely arbitrary."[9] Again he states:

> If part of the joint production cost is assigned to one of the products, it is a meaningless allocation. This is the most important thing to remember about joint cost accounting because it is this characteristic that makes it necessary to modify traditional cost accounting techniques.[10] ... Remember that the cardinal rule in joint cost accounting is: 'never show product-line profits.'[11]

Accountants have long considered accounting the language of business. Is the accountant going to be mute regarding communications needed by managers in their control of product mix? Accountants in this age seem to be forcing engineers and consultants to educate management in engineering efficiency by refusing to effectively convert the petroleum engineer's product improvements into the lanuage of cost accounting to the satisfaction of either the engineers or management. Dearden makes a further point:

> Where some control can be exercised over the mix of products that result from a joint production process, the accountant has additional responsibilities. He must give management information that will help in making decisions to maximize the profitability of the joint products. ... the products to produce are those with greatest contribution over unique costs.[12]

Dearden has rejected as arbitrary the price-relative method of cost allocation. His solution to the problem is

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[9]John Dearden, Cost and Budget Analysis (New Jersey: Prentice Hall, Inc., 1962), p. 47.

[10]Ibid. [11]Ibid., p. 52. [12]Ibid.

to deduct unique processing costs from the revenue realized on the sale of finished products. As pointed out by Lorig, this solution assumes

> ... that all the profits reflected in the latter sales values are earned prior to split-off. It assumes that the investment in the separate processing costs contributes nothing to the profits. Such an assumption is clearly illogical.[13]

Another assumption that could be drawn is that the investment in the separate processing is equally profitable with the original processing. That is, the gross profit margin on all special processing and normal processing is the same. The implications of this latter assumption can be disproved.[14]

In his article Lorig attempted to provide an aid to management by analyzing joint-production costs. He postulated that in some circumstances management must make a decision regarding further processing of a joint-cost product beyond the "split-off" point. When this is true, he suggested that special processing costs should be compared to a cost calculated on the relative-market-value method. Wherever the special processing costs would exceed the allocated cost, a decision to process further would be unwise since more profit could be obtained in some other area.

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[13]Arthur N. Lorig, "Joint Cost Analysis as an Aid to Management," The Accounting Review, XXX (October, 1955), 634-37.

[14]See Company M in Appendix E, p. 236.

This article is one of the few available in accounting literature on joint costs, and points up the controversial nature of the subject. In essence, Lorig theorized that whenever further processing costs exceed the gross profit margin at the existing level, a marketable semifinished product should be sold rather than processed further. Capital expenditures thus avoided should go into the more profitable processing areas.

Lorig immediately drew criticism from two sources. T. M. Hill contested the ability to demonstrate any inequality of profitability on special processing of joint products.[15] Further, he misunderstood Lorig's purpose in proposing a planning tool to determine whether or not to invest and raised the question of the transferability of committed capital from the old to the new projects. Gerald H. Lawson (an economic research student in England) also quickly entered the battle.[16] Lawson raised the theoretical question of any allocation at all, thus challenging Lorig for using a price-relative allocator. He stated:

> Implicit in this method is the assumption that every dollar invested in the production of the joint process is equally profitable. Whether or not one considers such assumption logical one cannot deny that it is highly arbitrary.

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[15]T. M. Hill, "Criticism of 'Joint Cost Analysis as an Aid to Management,'" <u>The Accounting Review</u>, XXXI (April, 1956), 204-5.

[16]Gerald H. Lawson, "Joint Cost Analysis as an Aid to Management ... Rejoinder," <u>The Accounting Review</u>, XXXI (July, 1956), 439-43.

> How can one rely upon figures which are derived from such an arbitrary basis? The element of arbitrariness having entered a calculation at the outset, it follows that the final answer will be arbitrary to some degree.[17]

Lawson also attacked Lorig's method of backing into a particular negative value. He asked how total cost could be $400,000 less than the special processing cost. Lorig replied to both men explaining more clearly his position. Following this, Lawson had a rejoinder, which Lorig again answered.

This lively exchange occurred because one dared to suggest the beginning of a real problem. The value of Lorig's article was to point out the unequal processing that takes place beyond the "split-out" point which most authors had previously ignored. Lorig did, however, err with respect to joint process; he stated, "Furthermore, the chance to vary their relative quantities in the short run is practically nonexistent."[18] While this observation was correct at one time, relative quantities are now reasonably flexible, within constraints. This flexibility is provided by the decision to apply or not to apply techniques which have been developed to upgrade refined products by altering their atomic structure (see the next section, page 23).

Engineers, managers, and consultants have made

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[17] Ibid.

[18] Lorig, loc. cit.

significant contributions in the field of managerial accounting. Early original contributions to the cost accounting field were almost exclusively made by nonaccountants.[19] What are consultants saying today about operating costs relating to joint cost accounting?

W. L. Nelson, Petroleum Consultant and Technical Editor of the Oil and Gas Journal, had these comments on operating costs.

> Our committee ... has been able to unearth only the most meager published information. ... the problem of allocating refinery operating cost to the many petroleum products is so complicated that a completely satisfactory method will probably never be available. ... accordingly, little is available in the literature and the staff of the Oil and Gas Journal is unable to come up with a single truly useful reference.[20]

Dr. Nelson went on to suggest a "complexity factor" which produces a partial volume allocation, but takes into consideration the operating-cost differences of the different refining processes.

If the refinery process could be simplified, and all processing beyond the original split-off point were done by different companies, the joint-cost-allocation problem would be simplified. This division of activity would clearly segregate the processing activity from the manufacturing

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[19]Robert E. Feller, "Early Contributions to Cost Accounting," Management Accounting, LV (December, 1973), 27.

[20]W. L. Nelson, "How to Allocate Operating Costs to Each Product," Oil and Gas Journal, LXI (August 5, 1963), 108.

activity. Two distinct problems would be apparent instead of one if it were possible for the processing and the manufacturing activity to be segregated. This segregation is impractical if not impossible, given existing facilities. The first joint-cost-allocation problem would be concerned with the division of the costs associated with the acquisition and simple processing of a barrel of oil. The second joint-cost-allocation problem would be specifically concerned with manufacturing (further processing) costs and their division among the resultant products.

THE MANUFACTURING NATURE OF REFINING

From the birth of the petroleum industry in 1859 the refining of crude oil was a process. The only significant changes which occurred during most of this time were changes in vessel (still) size and changes in the methods of providing heat. Historically nothing could be done to significantly alter the yield from the process. Attempts at cost accounting under these circumstances produced considerable frustration because of the joint-process-cost-allocation problem. When the early by-product period passed, and more than one desirable product was obtained, cost allocation with certainty was impossible. Astute accountants reached the conclusion, appropriate for that circumstance, that any allocation was arbitrary and cautioned against it.

More practical observers suggested price-relative allocations as a solution (although imperfect) to a pressing problem. How did this situation change; to what extent is the refining industry a manufacturing activity? William F. Schmeltz reviewed the historical developments in the refining industry which caused the change.[21] A frenzy of activity has taken place since the discovery of the Burton Process in 1909 (patented in 1913) which has as its guiding thrust the extraction of greater quantities of high-revenue products from the barrel of crude oil. Various processes have been introduced and patented which give refiners greater and greater flexibility in product yield. Since the lighter fractions of the crude-oil barrel have traditionally produced the highest revenues, research and development have focused on the production of these lighter fractions. Although research has been highly successful in enabling the refinery to upgrade products, it is not now possible to downgrade products heavier than the gasolines on an absolute basis. Flexibility does exist, however, since the manager can discontinue at will the upgrading process and return to the more natural yields. The percentage of upgrading is fairly small; however, the tremendous volumes put through the large refineries allow substantial quantities of alternate products to be considered for production. This

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[21]William F. Schmeltz, "Accounting and Management Control Practices in Petroleum Refining" (unpublished Doctor's dissertation, Western Reserve University, 1966) Distributed by Standard Oil Co. of Ohio, pp. 3-5.

flexibility creates the need for decisions. In turn the decision process generates a requirement for accounting information. Historically, (in other manufacturing areas) cost accounting with its managerial applications has provided the information needed to consider manufacturing alternatives.

The introduction of special processes to upgrade products led to differentials in processing costs. Dr. Nelson has clearly stated the fact that a price-relative cost allocator which completely ignores the processing-cost differences seems ill advised.[22] Figure 4.4, page 87, indicates the complexity of the product-mix problem.

When crude oil and refining capacity existed in abundance, the normal decision was to continuously upgrade products for higher-revenue production. This decision appears to have been followed by the industry until 1973. An interruption on the supply side of the equation, however, produced a new result. When there was a shortage of supply at all levels of production, price should have become the adjustment mechanism in an uncontrolled economy. When supply was scarce, resources should have been shifted to the product with the increasing price (increased demand relative to other products). This solution was prevented by direct government control.

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[22] W. L. Nelson, "Again - How to Allocate Operating Costs?" Oil and Gas Journal, LXIII (May 3, 1965), 123.

The true flexibility of the refinery was not demonstrated to the public until 1973 when the government ordered a change in the product mix. An increase in intermediate-product prices was allowed by the government to avoid the penalty associated with not upgrading product to one which produced higher revenues. The problems related to limited domestic-refining capacity and the curtailment of United States imports of refined products by some foreign powers ushered in a dual pricing scheme for domestic crude and a separate set of prices for foreign crude. These multiple prices coupled with the retention of petroleum products under Phase IV Government controls have presented the industry with a most demanding need for timely, accurate cost data. One accounting and planning executive indicated when interviewed that his entire cost accounting and reporting system had to be changed to satisfy the reporting requirements of the government.[23] The refinery is in reality a manufacturing plant with considerable flexibility in the short run and accounting systems have not always kept up with the rapidly changing external and internal reporting requirements. Any system which would meet today's complex requirements must be flexible. Professor Schmeltz clearly points out the need for a segregation of fixed and variable costs and one might be tempted to embark on a discussion of direct costing versus absorption costing if one tended

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[23] Name withheld by request.

toward rigid accounting views.[24] In this writer's opinion, the long-run solution to the extreme flexibility required of today's accounting system will demand modular construction in the accounting system.

The modular technique has been used to construct mobile homes, prefabricated houses, and other products where flexibility was a requirement. If used, the modular unit must be kept small and designed so that combinations are quickly possible. The accounting code used by most large firms would adapt to such a modular construction if, in addition to the regular code, a trailer code indicating the fixed or variable nature of a particular cost was added. In this way one could elect to sort either on the nature of the cost (i.e., fixed or variable) or on the nature of the account.

Regardless of the accounting methods used, there is flexibility in the output of today's refinery in the short run. Therefore, refining, once exclusively a processing operation, has now become a manufacturing activity with all the attendant cost-accounting and management-information requirements. While accountants in the past have generally adopted an "incapable-of-solution attitude" and consequently relied heavily on the price-relative allocation, other members of the firms have been experimenting with different approaches. Some of these

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[24]Schmeltz, op. cit., p. 96.

approaches will be briefly discussed in the following section.

CURRENT ACCOUNTING PRACTICES IN THE INDUSTRY

Two clearly separate areas require accounting information. Persons envisioning the financial reporting requirements have often pursued a fairly consistent approach to the valuation of inventory. This approach has generally taken the price-relative cost-allocation form. At the same time there is a need for internal information for decision-making purposes and for planning. In this area some accountants have cooperated fully and tried to assist the decision makers. Others have resisted departure from their traditional approach and have become ineffective in providing management with timely information in areas management has chosen to pursue. Other specialists (without advanced accounting training) have attempted to provide management with meaningful information. Reliable techniques seem hard to find. Several methods have been adopted and abandoned within the last decade but one in particular seems to be gaining prominence.

William F. Schmeltz in an unpublished dissertation strongly suggested the development of a financial costing model to solve the complexities of this accounting problem.[25]

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[25] Ibid., pp. 242-3.

He cautioned that it would be an expensive process but that existing technology was available and that such a computer model could be developed. This recommendation was sound, but the expense of such a model did not justify its creation merely for accounting purposes. Extremely sophisticated computer models had already been developed which would predict the output of each of many refinery operations with acceptable accuracy. There was a tendency for industry firms to use the existing model to the extent possible when developing the accounting model. These operational models used volume predictions and consequently most refineries, when forced by government agencies to report costs by product line, have adopted a heavy bias in favor of cost allocations based on volume. The theoretical problems associated with volume allocations are presented later in this chapter. While volumes appear to be a logical basis for allocating operating costs, they become quite illogical for allocating input costs.

The problem has been further compounded by Phase IV price controls. While a few companies suggested a price-relative cost allocator, most companies favored a volume-oriented cost allocator and this view has prevailed. In essence the volume-oriented cost allocator will have a price-equalizing effect among the various products since the new prices will be based on allocated costs and the allocated costs are based on volumes rather than the relative values of the products. The higher-priced products will have a slight tendency to reduce in price and the lower-priced products to increase in price. Although the price tendency can be briefly explained, the methods applied for implementation are anything but simple. An indication of the complexities of the reporting requirements under Phase IV controls can be observed if one examines Appendix D beginning on page 204. These complexities and governmental requirements will undoubtedly affect future accounting for the cost of refined products and will also lend additional weight to the volume-oriented joint cost allocations.

A QUANDARY IN THE APPLICATION OF THEORY

Direct questioning of personnel occupying management planning positions (economic planning departments or presidential, vice presidential levels) in the refining industry disclosed opposition to the use of a price-relative cost allocator for any management-decision purposes.[26] Those contacted were unanimous in expressing opposition to this method even for the allocation of the input barrel of crude which (in the opinion of those interviewed) represents approximately 80 to 90 percent of the cost of the refined products included in this study. Most of the executives interviewed preferred a total revenue to total cost comparison for decision purposes. If they were forced to give

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[26] A description of selection techniques and the number of firms contacted are presented on pp. 132-35.

profit by product line, most indicated a preference for a cost allocation based either wholly or primarily on volume as opposed to price. The volume allocator was never suggested by the interviewer, but was either identified as a crucial part of a computer program's allocation technique or was directly stated by the industry executive. All persons interviewed indicated knowledge of many alternate costing techniques, and a few indicated that their firms had specifically experimented with several in planning department studies. Those interviewed included persons holding the Ph.D. in economics and authors of industry papers on the subject of cost allocation.

The implicit assumption in the price-relative cost-allocation method that every dollar invested in the production of the joint process is equally profitable appears to be the most objectionable feature of the method. Processing costs are clearly not related to selling price since identical costs have been identified for products with different revenues.[27] Rapid and severe price changes among the product mix defeats temporarily the logic of the price relative cost allocator.

Rapid Market Value Changes and the Price-Relative Allocator

Recent increases in the price of foreign crude have removed some of the rigidity in the petroleum refining

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[27]See Company "M", p. 236.

industry. For years the refining industry in the United States has, with few exceptions, avoided domestic production of residual fuel oil.[28] The reasons will be detailed in Chapter 4. Basically, residual-fuel-oil production was uneconomical at the time. However, increased demand for residual fuel oil, coupled with a critical shortage in the supply of the product, produced contract negotiations in which the 1973 residual-fuel-oil prices were almost double the previous price. The most expensive equipment and processes used in the industry have as their purpose the upgrading of refined products to lighter fractions which were previously more valuable. Suddenly, the product which does not require and cannot benefit from all this further special processing becomes more valuable. Should it then automatically acquire a "cost" approximately twice what it was originally? Until the price of crude oil rises, it cannot be argued that the purchaser of the barrel of oil envisioned the end result of the sale at the time of purchase. This timing difference between the purchase and use of the barrel of oil invalidates the primary logic of the price-relative approach.

This problem becomes even more complex if technological advance, rather than ecological or political constraint, causes the change. A detailed discussion of

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[28]Texaco Inc. is the only major exception, having consistently produced residual fuel oil.

such a change is presented in the section on page 39.

Other Allocation Methods

One of the simplest alternatives to the price-relative allocator is an allocation based on volume (total cost divided by total units). This method seems to be gaining acceptance over more complex methods. Although well-suited to the allocation of processing costs, this method's use is questionable when one considers the cost of the barrel of input crude. Can it be logically argued that the purchaser of a barrel of oil is willing to pay the same price for the lowest revenue potential in the barrel as for the highest? If the components could be purchased separately, would any knowledgeable purchaser pay more for the residual-fuel-oil portion than it could be sold for after processing? This method creates conflicts greater than the ones presented in the previous section.

Management-accounting authors have cautioned against the arbitrary nature of the price-relative cost allocator. Emphatic statements have been made denying any managerial input quality to profit figures reported on a product mix basis. Accountants have presented an argument against the product of their own logic. With the acceptance of these comments there remains little value to the price-relative method of allocation. Inventory valuation is the one small exception. At this point most accountants have finished their search. Schmeltz has compared inventory valuation for a "model" refinery, under eight different methods, in a study which has been widely circulated within the industry.

> Inventory valuations range from a high of $5,711,880.79 under the Barrel Gravity Method to a low of $4,957,182.10 under the Replacement Cost Method. Expressed as a percentage, the respective figures would be 87.48 percent and 75.92 percent of the market value of the ending inventory. ... No matter what method is used, the dollar amount of the possible error is small in comparison.[29]

This study included the joint-products method (with and without blending), the by-products method, the replacement-cost method, the product-analysis method, the barrel-gravity method, the crude/gravity and process/gallonage method, and the crude/BTU and process gallonage methods.

EXISTING RESEARCH ON COSTING PRACTICES

Most of the methods analyzed by Schmeltz were used or had been suggested as possible solutions to the allocation problem. However, most of these methods have now been discarded, are not used extensively, or are used with reluctance. New volume-oriented or differential cost techniques seem to be more acceptable to operating personnel. No one is entirely satisfied with the methods in use. Instead, the search continues for the least-objectionable method which bears some correlation to actual operating conditions. The study of the eight cost-allocation

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[29]Schmeltz, op. cit., p. 96.

techniques by Schmeltz appears to be dated to such an extent as to make the current usefulness of the study questionable. The age of this study leaves a void in the literature which will be difficult, if not impossible, to fill.

Phase IV price controls have made costs a direct determinant of price; consequently, any careful scrutiny of cost data at this time would arm competitors with pricing information and would undoubtedly be resisted by the oil companies. Some data could be obtained from the reports which are filed with the government but this information by itself would be of extremely limited value.

Methods other than those mentioned above have been considered by operating personnel and rejected (for example one company considered an allocation based upon atomic weight). The heavy use of computer models has introduced a trend toward the use of a volume or a modified volume method. How can one state the problem more precisely?

A MORE PRECISE STATEMENT OF THE PROBLEM

Is it possible to evaluate quantitatively the logical quandary in which we find ourselves? The traditional accounting justification for the price-relative allocation regards the barrel of oil as a bundle of products. (See Figure 2.1.) Accountants effectively argue that the knowledgeable purchaser of a barrel of oil envisions the use of the barrel at the time of acquisition; therefore, the maximum price one is willing to pay for the

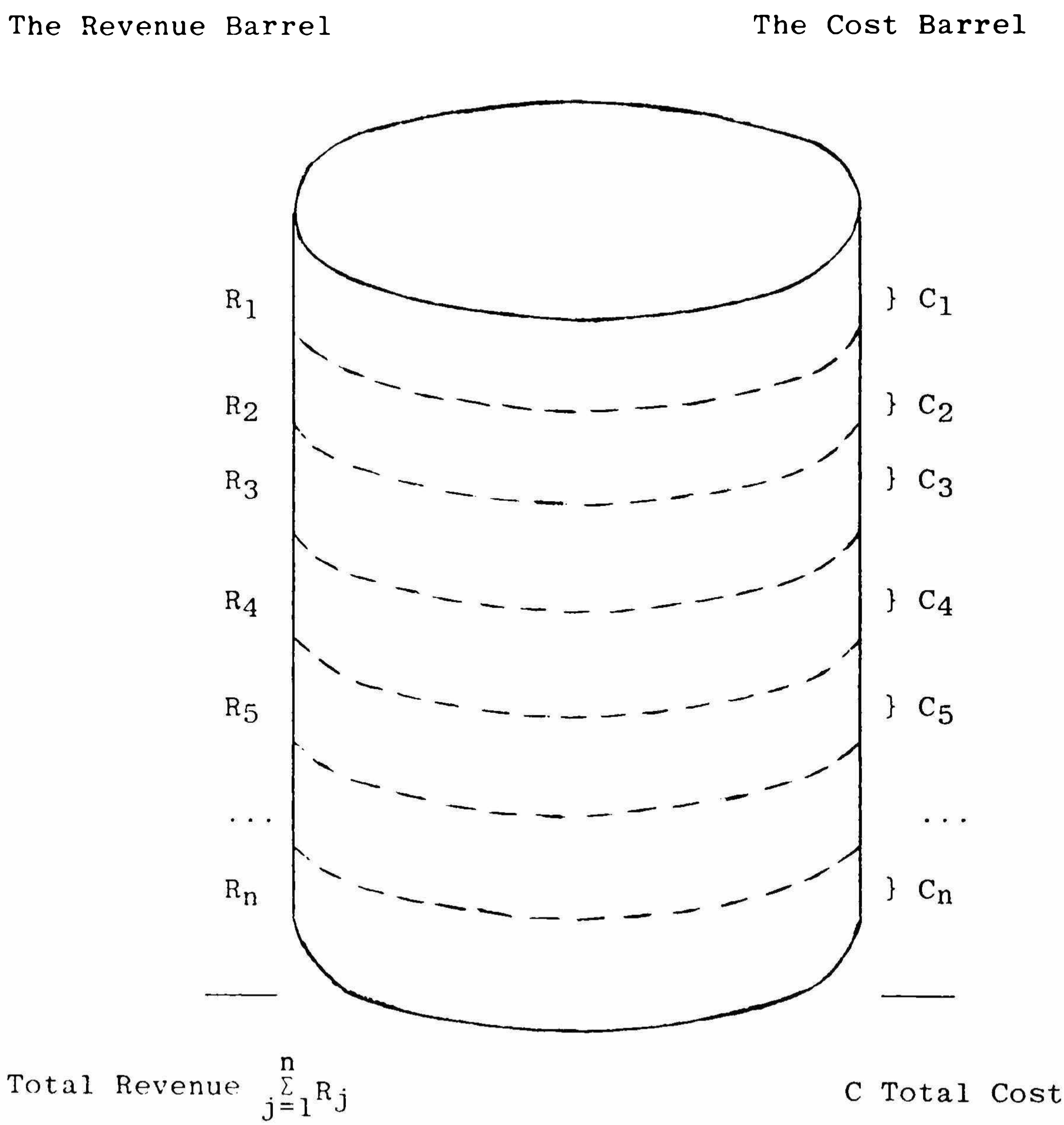

Figure 2.1

The Envisioned Barrel

barrel is the sum of the values of the imagined component parts. Since the buyer thinks he knows the selling prices of the various potential products, and since he is quite familiar with his own operating costs, he would not choose to pay more for the barrel than the sum of the amounts each portion was worth, i.e., a sum which would allow a "reasonable" markup on each of the component products. The allocated cost of each component product would thus become price relative. The ratio of each component's revenue (R_i) to total revenue ($\sum_{j=1}^{n} R_j$) would be multiplied times total cost (C) to arrive at that component's cost. Expressed quantitatively (refer to Figure 2.1 and Formula 2.1), cost becomes:

$$C_i = C\left\{\frac{R_i}{\sum_{j=1}^{n} R_j}\right\} \qquad (2.1)$$

Any change in the revenue barrel either in total or in product mix would cause a change in all costs under this accounting method. For example, assume that refinery engineers were successful in converting product C_5 into a totally new product with much higher revenue, (referred to as revenue R_5'). How is the cost barrel now envisioned? All cost allocated to the component parts have changed by recomputing formula 2.1.

$$C_i' = C\left\{\frac{R_i'}{\sum_{j=1}^{n} R_j'}\right\}$$

In the illustration two important variables, technology and time lags, have thus far been ignored. The need for these variables becomes apparent if the problem is considered from the engineer's point of view. Petroleum engineers are assumed to be successful in the development of a new product by modifying an existing component. One old component is no longer produced, and the portion of the barrel of oil that used to go to that component is now used to produce the new component. No change has occurred in the cost of the barrel of oil. The engineer is successful in producing more revenue from the same crude-oil portion by incurring slight additional processing cost. Instead of reporting the additional revenue and cost associated with one component's conversion, the accounting method reallocates all costs and produces a new but equal profit margin on all products.

Engineers argue that a new formula (2.2) is needed for cost allocation. With such a view the revised cost should be

$$C_i' = C_i + \Delta C \tag{2.2}$$

where ΔC is the addition to cost due to product modification. This addition to cost would include both the additional processing cost and depreciation of the additional processing equipment required. Several different but actual refinery modifications which were approved by refinery management were described by industry representatives. Perhaps accounting reports should be capable of reflecting these potentially profitable events by reporting (internally) a profit from the engineering conversion.

The illustration is clearer if reference is made to Figures 2.2, page 40, and 2.3, page 42. At least two possible situations exist. The newly produced product could be produced for an existing market or for a new market (i.e., although the product is new to our refinery, it may or may not be new to the consuming public).

A New Product

Figure 2.2 attempts a graphic illustration of a product which is new to the consuming public. Revenue R_5 and cost C_5 exist at time t_o. These figures hold constant during time period a. A technological innovation is implemented in production by only one firm at time t_1, creating a new use for input barrel component 5 with cost C_5 (refer back to Figure 2.1). The decline in revenue from point t_1 to t_2 represents competition from other companies who have successfully copied the process before news of it is published. As discussed, the engineer attempts to account for the change by using only time period b on Figure 2.2, while the accountant considers only time periods a and c.

New entrants into this new market area may be discouraged if the initial producer restricts revenue to R_5'''. This pricing policy would eliminate a rapidly declining revenue in the early portion of time period b. General dissemination of the technology takes place

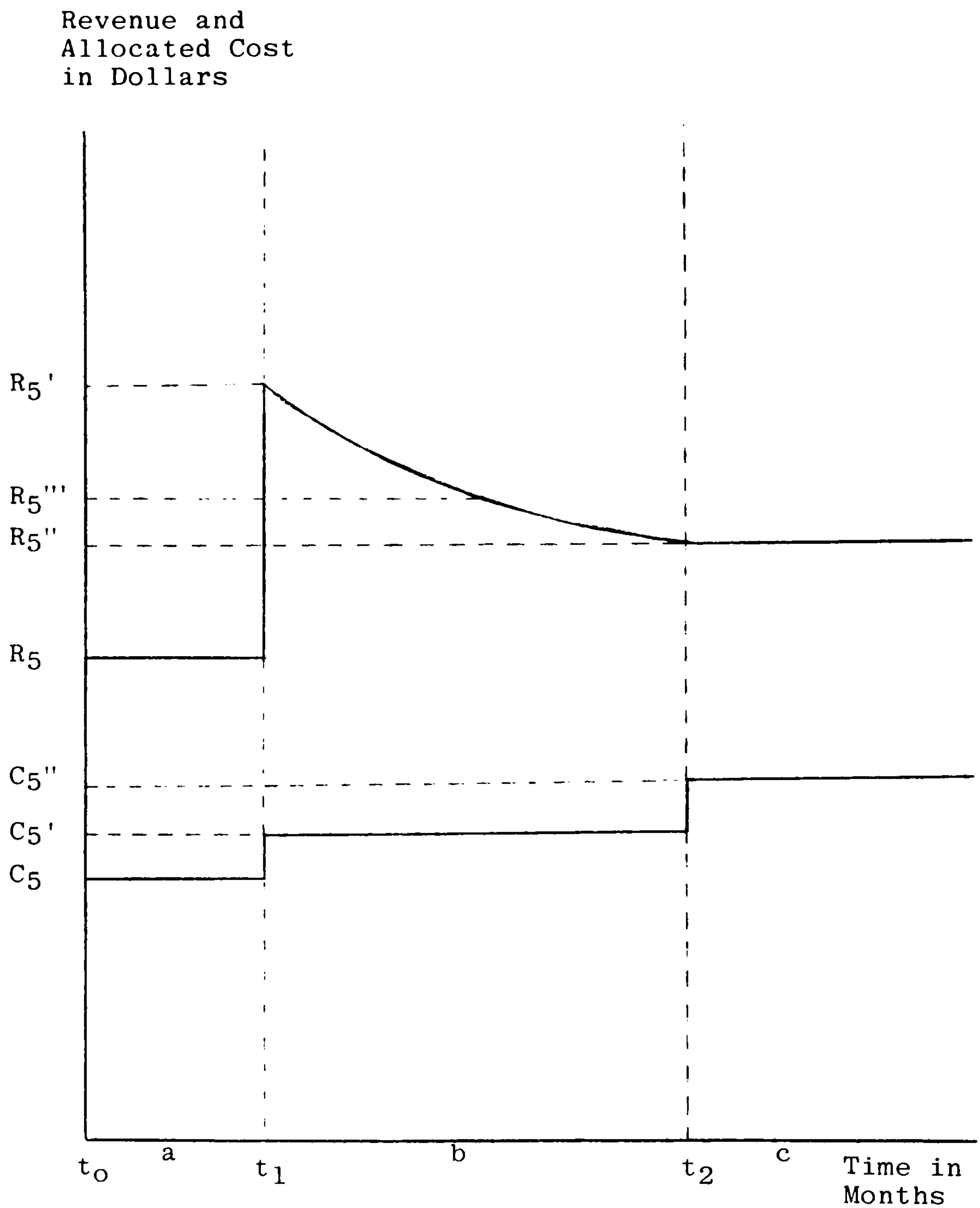

Figure 2.2

Technological Innovation Implemented by
a Single Firm with a New Product
Sold in a New Market

in trade journals at point t_2. At this time it is assumed that the price of crude oil will increase to the maximum possible as a reflection of the increased value of the products. However, during time period b there is no change in crude-oil cost due to the technological advance because the firms posting the price are unaware of the technology. It is therefore theoretically impossible for the accounting cost reallocation to be valid in the short-short run, since that reallocation does not take period b facts into consideration.

An Existing Product

Assuming that the engineers have created a process to upgrade low-revenue products to existing higher-revenue products with existing prices rather than an entirely new product, Figure 2.3 attempts to portray the time sequence. When production of the upgraded product was started at point t_1, the higher-revenue R_5' (equal to the going rate) would be sought. The firm must be cautious with volumes if the existing favorable price is to be maintained. Unless the existing market is experiencing supply shortages, the introduction of large volumes of product would depress price. If a few other firms discovered the process and introduced greater volumes into the market, the lowering of price that would ensue would indicate to the developer of the process that other firms had knowledge of the process. This knowledge would encourage publication in technical

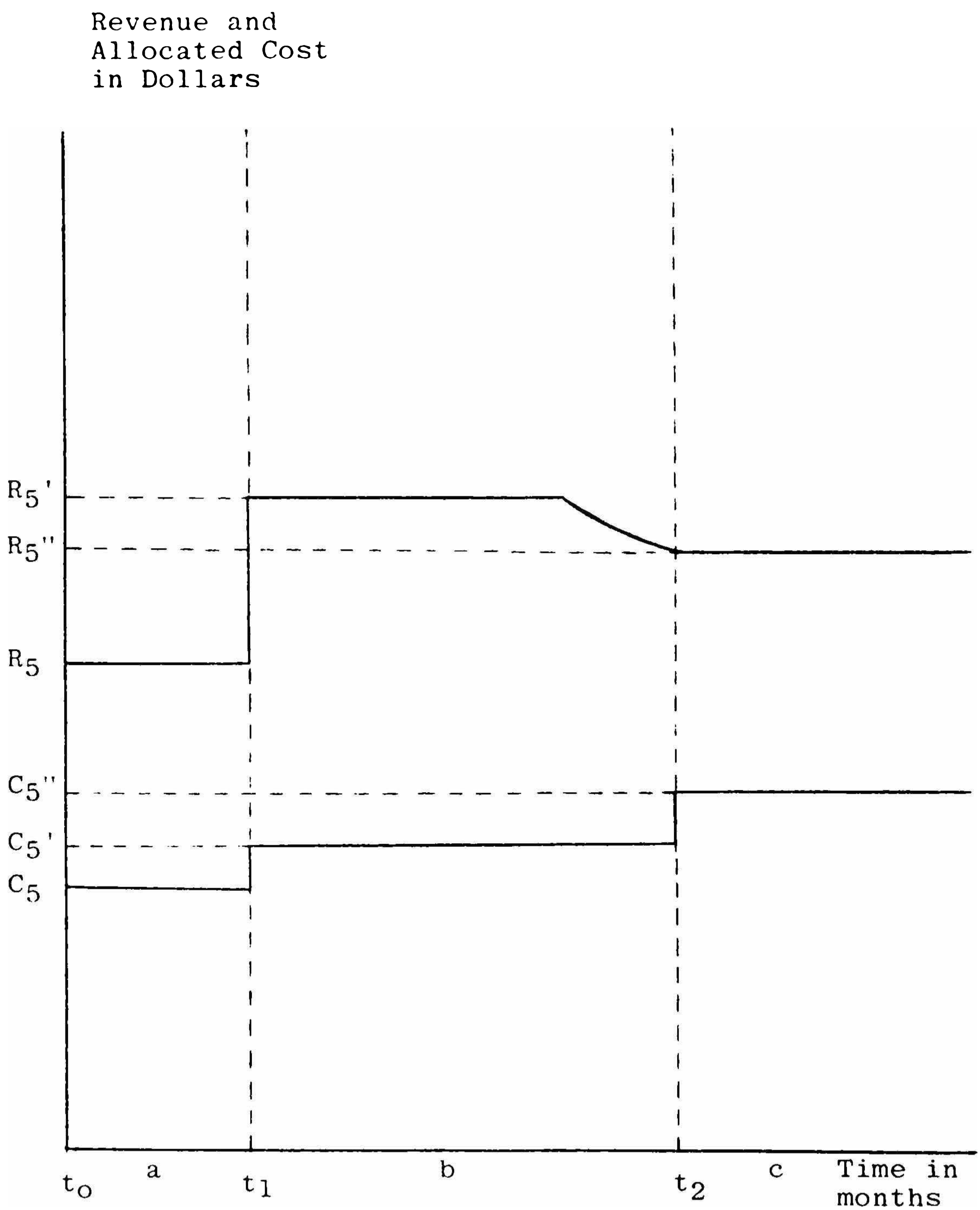

Figure 2.3

Technological Innovation Implemented by
a Single Firm with a New product
Sold in an Existing Market

journals. After publication in the technical journals, the price of crude oil would rise to reflect the increased revenue potential, and the price-relative cost-allocation logic would again be valid in time period c.

Time Period b

In effect, then, two problems exist. How does one account for change in refinery production both in the short run and also in the short-short run? No similar problem apparently exists in any of the other well-known areas in which price-relative joint-cost allocation is used. There is no time period b in the cost allocation of a side of beef or a parcel of land since there is no manufacturing activity to allow an innovation. In these two illustrations the short run and the short-short run situations previously described do not exist simultaneously. There is no period of time (b) when the seller is not aware of the full range of products obtainable from the raw material.

The presence of time period b has caused difficulty in accounting for petroleum-refining operations. Most firms of any size are now using computer models to simulate refinery operations and to assist them in obtaining information for decision-making purposes. The outputs of the models are expressed in volumes of production. These two factors have combined to produce a strong bias in favor of a volume allocation of joint cost either directly or in some modified form. Once this accounting procedure is adopted, the short time period b is accounted for with meaning, but the longer time frames a and c are handled in a logically inconsistent manner.

In addition to this accounting framework it is also desirable to review economic theory relating to the refining industry before considering the factors causing price to have semirigidity. Such an economic review follows in Chapter 3.

Chapter 3

WHOLESALE PRICES IN THE PETROLEUM REFINING INDUSTRY

The petroleum refining industry has all the outward appearance of the classical oligopoly structure (refer to Appendix A which lists refiners by their 1973 capacity). The top eight companies each controlled more than 750,000 barrels per day of refining capacity. The next seven companies each controlled more than 200,000 barrels per day of refining capacity and together these two groups (fifteen companies) represented 75 percent of the total industry capacity at the beginning of 1973. Only seventeen more companies have the capacity to produce over 50,000 barrels per day. The production activities of the many small companies which remain should have little effect on price under most theories of oligopoly. Bain has labeled the control of 50 to 80 percent of total refinery volume a concentrated oligopoly.[1] What is the current nature of oligopolistic competition in petroleum refining?

A brief review of economic theory related to oligopoly structures is essential before an answer to this

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[1]Joe S. Bain, The Economics of the Pacific Coast Petroleum Industry Part I: Market Structure (Berkeley: University of California Press, 1944), p. 211.

question can be attempted. Several theories have been advanced which attempt to explain the oligopoly market. These theories fall into two basic categories, the kinked-demand-curve approach, and multiple-cause approaches.

Criteria for the acceptance of economic models are often disputed. Some persons insist that to be valid a model must be merely a reasonable representation of historic activity so that this activity is "explained" by the model. (The multiple cause approaches often fall in this category). Others would insist that to be practical an economic model must be primarily capable of predicting the logical anticipated actions of the firm if the inputs to the model are available (for example, the kinked-demand-curve approach). Although the current study is historical, covering the activities in the refining industry which have produced alarming "energy crisis" headlines, both approaches will be considered. Do industry activities leading up to this emergency closely follow the suggested patterns for oligopolies? If not, do any <u>components</u> of the economic theories advanced explain the activities of the industry over this time period? The single-model approach will be considered first.

A SINGLE-MODEL APPROACH

The "kinked" demand curve attempts to explain in a single model the actions of all oligopoly markets. Proponents of this approach have generally used the

Hall-Hitch or the Sweezy[2] solution which introduced the kinked demand curve with its accompanying "imaginary" demand curves. The price elasticity of demand, formula 3.1, is used to evaluate competitor response.

$$(R) = \frac{\%\Delta QA}{\%\Delta P} \quad (3.1)$$

The kink in the curve is produced because competitors in the oligopoly market view demand as elastic when they consider price increases (the price elasticity of demand $(\eta)>1$, i.e., a percentage increase in price will cause a greater percentage loss in quantity), but when they consider price decreases, demand is viewed as inelastic (the price elasticity of demand $(\eta)<1$, i.e., a percentage decrease in price will cause a smaller percentage increase in quantity demanded). This dual view of demand leads to the conclusion that competitors would not "follow" price increases and the relative elasticity of the demand would significantly decrease sales volume. Competitors would, however, meet price decreases, thus reducing total industry revenue with little or no gain in market share to the firm initiating the price change.

As illustrated in Figure 3.1, the demand curve for price increases is dd' and the demand curve for price decreases is DD'. This difference of attitude between price increases and decreases causes the demand curve to be dWD'

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[2]Paul Sweezy, "Demand Under Conditions of Oligopoly," Journal of Political Economy, XLVII (August, 1939), 568-73.

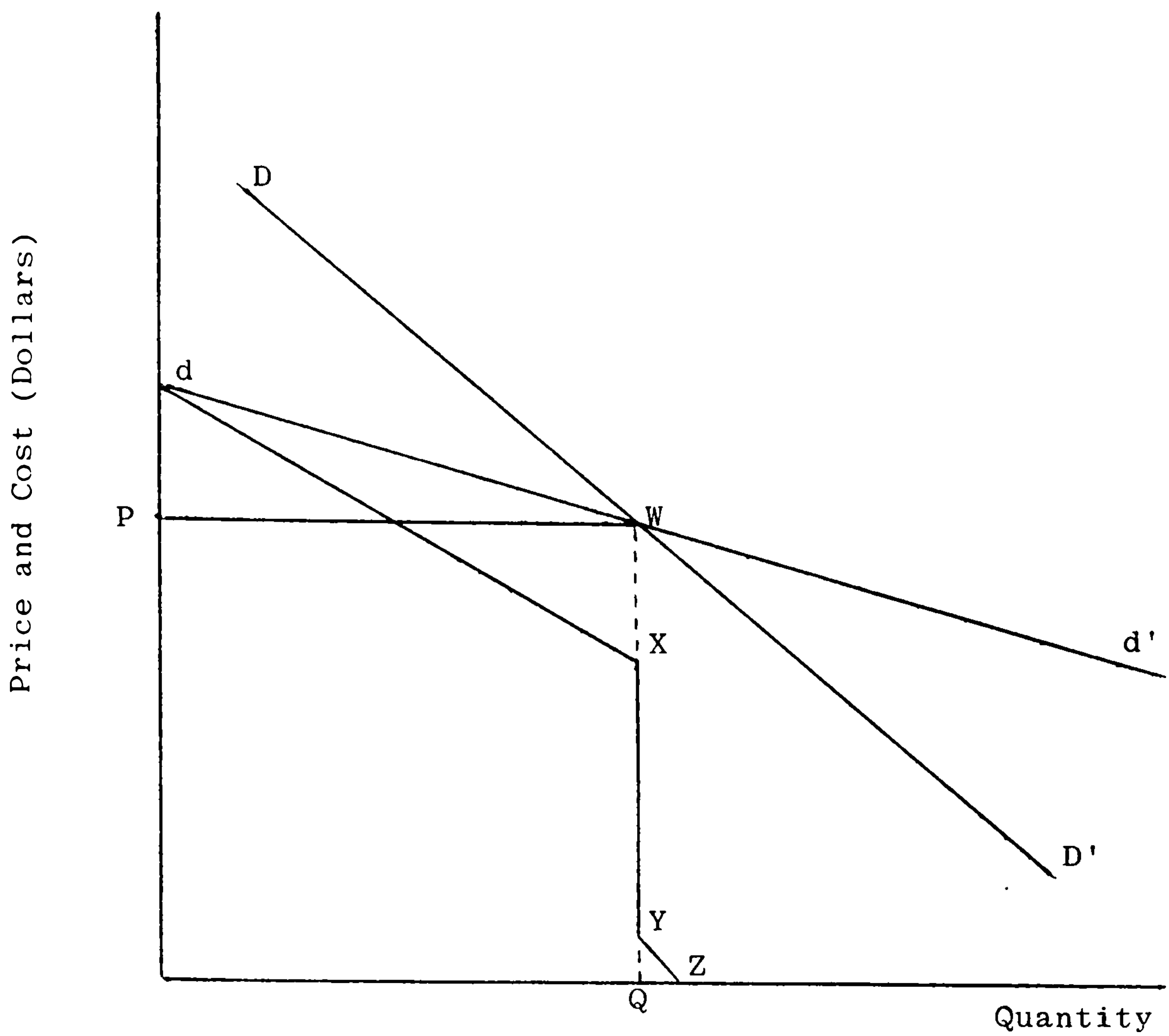

Figure 3.1

Kinked Demand Curve

and introduces a vertical section in the marginal revenue curve, represented by line segments dXYZ. This model does not explain why a price is set where it is, but merely demonstrates the tendency for a common price throughout the vertical portion of the marginal revenue curve. In Ferguson's words, "The Sweezy thesis, accordingly, must be regarded as an ex-post rationalization rather than as an ex-ante explanation of market equilibrium".[3] The fluctuations in price which can be observed by examination of Figure 4.1, page 79, appeared contrary to the price stability suggested by the Sweezy model. Figures 4.1, 3.1, and 3.3 were therefore presented to refinery-industry representatives to obtain their explanations or responses. The responses of the executives interviewed suggested that either a modification must be made in the kinked curve model or the model is not appropriate to the oligopoly structure existing in the refining industry during the period under observation. Their responses also support the observation that the behavior of the firms for the decade 1962-1972 indicates a growing conviction on the part of cut-rate distributors of refined products that price competition is in their best interest and is effective in wresting a larger market share from major oil companies. Those companies interviewed which utilized cut-rate pricing policies were

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[3]C. E. Ferguson, Microeconomic Theory (Homewood, Illinois: Richard D. Irwin, Inc., 1969), p. 315.

quite certain of a positive effect of price reduction on market share, and consequently it was neccessary to modify or discard the sharp difference in the two imaginary demand curves. (See Figure 3.1.) The following material demonstrates this change in attitude utilizing the Sweezy model.

Assuming that the demand curves are only modified, they might appear as represented in Figure 3.2. In this figure the inelastic portion of the model is considerably more elastic than in Figure 3.1. The effect is to narrow the vertical portion of the marginal-revenue curve. If, as Sweezy has proposed, the pricing of the oligopoly structure is related to short-run marginal-cost curves which lie within this vertical portion of the marginal revenue curve, and if one further assumes that an attempt is made to prohibit entry in a manner consistent with Bain's suggested entry restricting pricing scheme, one could logically expect to find the short-run marginal-cost curve relatively low in the short segment between X and Y.[4] Under these circumstances, if the independent refiners miscalculate their short-run marginal cost, or if the demand schedule is not well estimated, they may erroneously believe this cost to fall somewhere on the line segment YZ. This error would definitely lead them to the conclusion that price

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[4]Joe S. Bain, "A Note on Pricing in Monopoly and Oligopoly," American Economic Review, XXXIX (March, 1949), 454-64.

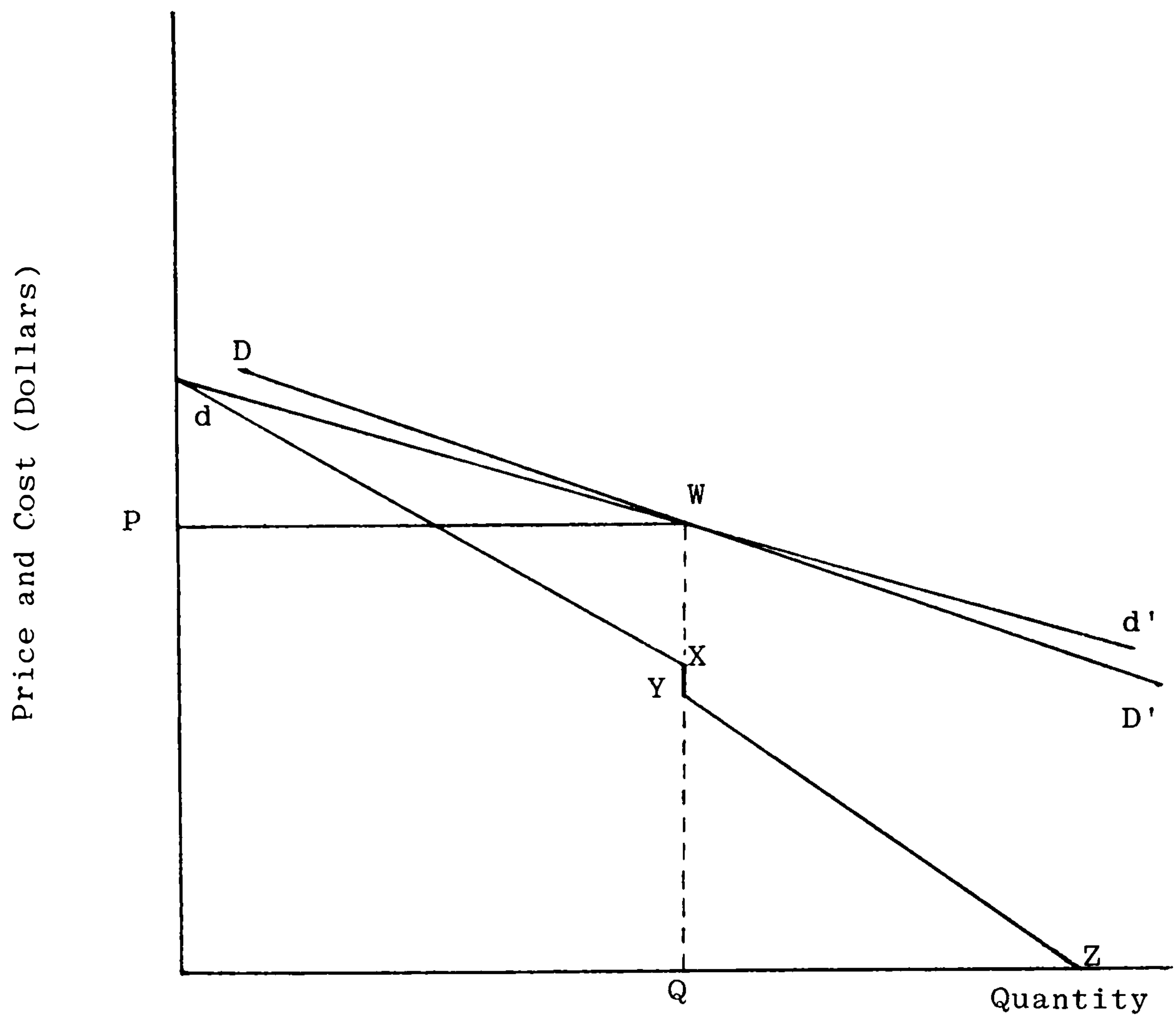

Figure 3.2

Kinked Demand Curve
Modified

competition would be effective.

The possibility exists that even a properly calculated marginal cost could fall in this region. If the long-run average cost curve of refineries is U-shaped, the economies of scale for the large refiners might not be as great as anticipated by the United States Government. The possibility of marginal cost falling on line segment YZ is more plausible if one also considers the possibility that independent refiners frequently do not have exactly the same product mix as major refiners.

The smaller independent refinery, although inefficient in terms of "Best-Practices Production Techniques" as suggested by Salter,[5] may be reasonably efficient in terms of the product mix for which the refinery was originally designed. Many of the technical improvements in refinery configuration have as their primary thrust the ability to produce a higher percentage of higher revenue products. Salter's study was primarily directed toward improved productivity, i.e., the efficient substitution of improved capital equipment for labor so that more product could be produced with fewer man-hours and less capital. Since the conversion of low-revenue products to high-revenue products could reduce the volume of low-revenue products for a given geographical area, an existing refinery with the

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[5]W. E. G. Salter, Productivity and Technical Change (New York: Cambridge University Press, 1966), p. 13.

ability to produce this product may find its relative position on this range of products strengthened by the new refinery. Concurrently the smaller refinery will probably find the higher-revenue products in greater competition with the output from the new refinery. Several areas where small refineries may have compensating advantages were reported by an informed representative of Company "U" and are presented on page 222. Salter acknowledged that trade-union restrictions or severe shortages of natural resources may both be valid reasons for refuting his contention that curves representing alternate best-practice techniques never cross. If these observations are valid and the United States Government attempts to equate the economies of the large and small refineries, any miscalculation on the part of the United States Government may temporarily give the small refiners an actual marginal cost advantage. In either event (whether real or imagined) an independent refiner who considered himself to be operating in the portion of the marginal revenue curve between Y and Z of Figure 3.2 would definitely adopt policies of price competition. In fact a refiner in this circumstance could conceivably envision himself a price leader in a rather limited, geographically segmented, market.

THE MULTIPLE-CAUSE APPROACH

Other writers have suggested that there may not be one model which can accurately describe the complex interworkings of today's oligopoly markets. Lanzillotti, after extensive interviews with corporate executives, has suggested four major pricing objectives as an alternative to a single model with one profit maximizing objective. Lanzillotti's four objectives are [6]

1. to achieve a target return on investment
2. to stabilize prices and margins
3. to meet competition
4. to achieve a target market share.

Constraints

The Lanzillotti pricing objectives were integrated with several others in a paper entitled, "Pricing in Big Business," by White, Market, and Taylor.[7] In essence, these writers present a feasible area for the solution of oligopoly pricing problems (refer to Figure 3.3). The feasible area is constrained by management-determined minimum (QL) and maximum (Q1) market share, a demand curve (d), and the lowest acceptable profit level (πL). The authors suggest that the pricing policy adopted by the firm be the one that will maximize profits within the feasible region. The point of tangency between the highest possible isoprofit curve (π1) and the feasible area determines the

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[6]Robert F. Lanzillotti, "Pricing Objectives in Large Corporations," American Economic Review, XLVII (December, 1958), 921-40.

[7]Leonard White, Donald Market, and Phillip Taylor, "Pricing in Big Business," (paper presented at the Southwestern Economics Association meeting, April, 1972, San Antonio, Texas).

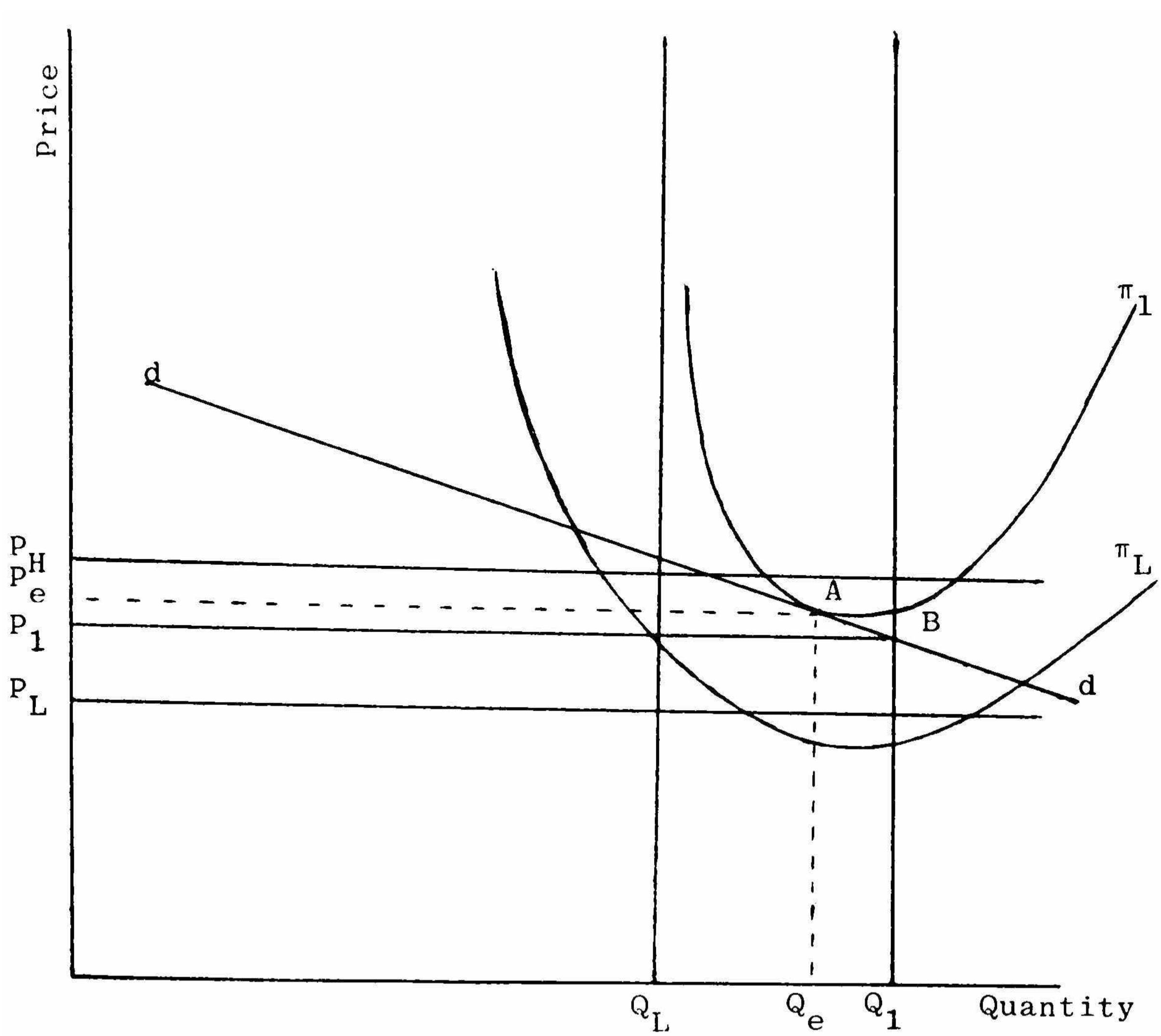

Figure 3.3

Feasible Area Solution

normal mathematical solution to price and quantity. In Figure 3.3, point A is the mathematical solution to this problem. This model is useful, even though caution in use may be in order, since it allows the introduction of additional constraints. Discussions with representatives in the industry disclosed an apparent bias on the part of industry personnel in favor of operating at what they considered to be an optimum level of capacity despite the effect on price. (See the marginal cost discussion on page 63.) This policy represents an additional constraint and would cause the mathematical solution to move to point B so that the refinery could maintain optimum levels of capacity whenever physically possible. If Q_1 is that optimum level, then additional output Q_e would be pursued even if the product had to be sold at a lower price (P_1).

A combination of activities which tended to suppress price and establish artificially low prices over a period of time are presented in the next chapter, but these actions have an impact on this economic model. Among other price depressors, a major change in consumer attitude toward off-brand and cut-rate operations appears to have shifted demand for major refiners' branded products as illustrated in Figure 3.4. Original demand represented by line segment d is replaced by demand curve d' which produces an economic solution for the firm at point Y. The loss in output at point Y is not acceptable since refiners prefer to operate at more efficient levels. (See the marginal cost section of

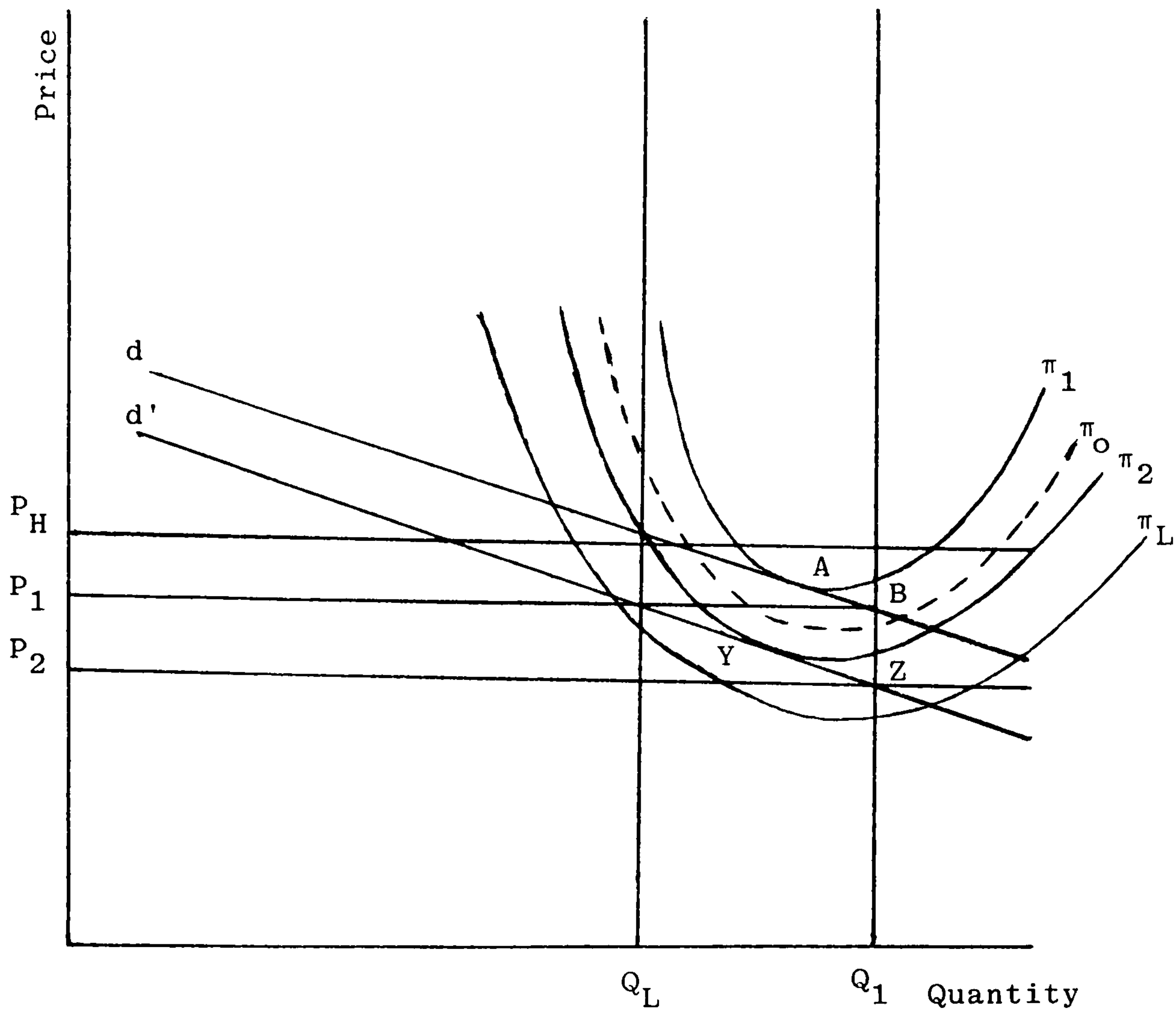

Figure 3.4

Feasible Area Solution With
Government Constraint

this chapter on page 63.) Product dumping follows and causes price to further decline toward point Z. This economically unstable situation is described in greater detail later in this chapter. To reach point Z might require several cycles of demand loss.

General inflationary pressures and increased specific costs combined to prevent prices from going below P_2; however, it should be noted that at this level isoprofit curve π_0 does not appear to be attainable. This curve represents the lowest profit which will provide for the generation of the future capital requirement for totally new refinery facilities.

When prices reached point Z the United States Government used the news media to force price rollbacks by threatening the removal of oil-import controls. This action effectively prevented the industry from raising prices. Thus a new external constraint was introduced which held return on completely new refinery investment to an effective minimum. This investment-retarding effect can be seen if the actual United States refinery capacity is examined in Figure 4.5 on page 124.

This model has introduced company policies or objectives as constraints and is a useful tool because empirical evidence supports the position that external forces have introduced additional constraints in the petroleum-refining pricing scheme.

Entry

Bain lists three necessary conditions for easy entry into an oligopoly structure.[8] One, established firms should have no absolute cost advantage over new firms. Two, economies of scale should be negligible. And three, no product differentiation advantage should be held by established firms. The absolute cost advantages which exist in the refining industry appear to be partially offset by United States Government activity.

Although an "absolute cost advantage" usually refers to input prices (or costs) that are appreciably lower for the established firm, an extreme example would be a complete lack of availability of input to new entrants at any price. When raw materials were in short supply, major oil companies attempted to control production and reserve their crude-oil production for their own refinery operations. These efforts were partially overcome when the United States Government insisted on taking its royalty in kind and delivering it to the small companies. For a short time during the 1973 crisis, regulations required that all refineries operate at the same percentage of capacity. Those with the foresight to provide for their own crude needs were thus penalized for that management skill by being forced to sell crude oil to independents at fixed prices while their own refineries

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[8]Joe S. Bain, Barriers to New Competition (Cambridge, Mass.: Harvard University Press, 1956), p. 12.

could have been operated at more efficient (normal) levels had they been permitted to retain their own crude oil.

Knowledgeable persons in the industry (those capable of operating a refinery) stated that production techniques are well known and do not deter entry.[9] Product differentiation, however, was a significant factor until economic advantages given to small refineries allowed them to supply independent marketers with low-cost product. The upset of the delicate balance started an unstable chain reaction, which will be described under the marginal-cost section of this chapter (on page 63). Once the balance was upset, a fairly continuous supply of cut-rate products was available at a price difference that substantially negated the accumulated preference of many buyers for established brand names.

The third major obstacle to entry (economies of scale) was rather extensively offset for sustained periods by import advantages given to small refiners. These took the form of low-cost crude oil. The crude-oil input has constituted 80 to 90 percent of the total finished-product cost. Although large-scale economies have necessitated consistent increases in plant size over the years, crude-oil cost has remained the most significant cost factor in the refining operation.

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[9]For an example see comments of a representative from Company "U" page 222.

PRICE LEADERSHIP

Price leadership in petroleum refining seems to have undergone rather drastic changes during the decade 1962-1972. Little effective leadership was manifested by the major oil companies although attempts were made. Price increases were announced and then rolled back due to direct United States Government pressure. Unofficial price wars seemed to be the order of the day.

A review of the important market features required for price leadership in an oligopoly sheds light on the confusion of this era. As suggested by Markham, the requirements for price leadership are:[10]

1. There must be relatively few firms in the industry.
2. Entry into the industry must be restricted.
3. The industry product must be fairly homogeneous.
4. The elasticity of demand for the product should either be close to or less than unity.

In addition, Dean states that to qualify as a price leader the following circumstances are required:[11]

1. a substantial share of the market
2. a strong reputation for sound pricing decisions
3. a demonstration of initiative in pricing policies.

There are relatively few firms in the refining industry. Its products are fairly homogeneous. Government regulatory agencies have attempted to remove restrictions on

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[10]Jesse W. Markham, "The Nature and Significance of Price Leadership," American Economic Review, XLI (December, 1951), 901-2.

[11]Joel Dean, Managerial Economics (Englewood Cliffs: Prentice Hall, 1969), p. 433.

entry. With the exception of market share, which has been carefully controlled by antitrust policy so that no one firm has succeeded in obtaining even 10 percent of the market, the other prerequisites listed by Dean for price leadership seem to exist in the industry.

Historically, one of several dominant firms (those with over one million barrels of productive capacity in 1973) has set prices until the period covered by this study was reached. During the last decade there is evidence that effective price leadership by the dominant firms was attempted but failed. The primary reason for this appears to be the usurping or controlling of price leadership in the industry by the United States Government. Several companies rolled back price increases because of thinly veiled threats by members of the United States Senate to eliminate the protected price of crude oil in the United States by removing the oil-import program. This activity, coupled with the direct savings by smaller refineries made possible under the import allocation program, reduced costs enough for some independent marketers to adopt pricing policies contrary to those policies adopted by major oil companies. Significantly, these independent marketers survived the ensuing price wars. Paolo Sylos-Labini, an Italian economist, suggested that

> Although there is not a unique equilibrium situation, we can indicate the general price tendency; the price tends to settle at a level immediately above the entry-preventing price of the least-efficient firms which it is to the

> advantage of the largest and most efficient firm to let live.[12]

Clearly, government intervention has rendered this observation invalid in the petroleum industry for the period under examination. Firms existed which were in effect an irritant to the sensitive pricing structure but which could not be removed by the major refining firms.

MARGINAL COSTS

The history of economic thought provides us with an early indication of the nature of marginal cost. One classic explanation of rent explained rent as a premium paid for productive land when the expansion of the economy required marginal land to be put into production. For an adequate return to exist on the marginal land a rather generous return existed on the more productive land. Land-owners, keenly aware of this difference, charged high rents to absorb the difference and to make production equally profitable for the laborers on all lands involved. The classical quotation by Ricardo, "Corn is not high because rent is paid, rent is paid because corn is high," was the embodiment of this marginal-cost principle. Economics has come a long way from the subsistence wage of that era; however, a grain of truth exists that does not seem to be

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[12]Paolo Sylos-Labini, Oligopoly and Technical Progress, Elizabeth Henderson (trans), (Cambridge, Harvard University Press, 1969), p. 50.

fully emphasized when discussing marginal costs. If a decision is made to allow inefficient refiners to exist (the marginal land), then without arbitrary discrimination, higher returns (rents) should be expected from major refiners since they are more efficient.

General Considerations

Most economic literature suggests that if product discrimination can be maintained, price policy should provide for reduced prices until marginal costs are equal to marginal revenue. At this point no further discrimination is required and no lower price will be effective in maximizing profits. Usually foreign markets and new distribution channels using little-known names as opposed to the recognized or branded products are suggested as effective means for price discrimination.

For a number of years major refineries have promoted product differentiation quite successfully and have built up in the minds of customers the image of heterogeneous products in a homogeneous market. As long as price differentials remained relatively small in the mind of the purchaser he preferred the imagined superior product even at a higher price. Off-brand marketers, however, fortified with low-cost products, succeeded in passing the point of mental equality in this pricing scheme. Their prices were low enough to induce a significant portion of the branded market to try their products because of the price advantage. All of the firms questioned agreed that the illusion of the superior product was broken in the minds of a significant portion of the consuming public. Thereafter, customers switched to new suppliers any time price was low enough to offset inconveniences caused by new marketing forms. Operating economies were available to cut-rate marketers because their facilities were designed for minimal service and self-service operation, which eliminated substantial overhead and operating cost. The only other problem to be surmounted in order to consistently better major oil companies' price structures was the need to ensure an adequate supply of low-cost product. In this area the majors assisted their competitors.

What is the marginal cost of operating a modern refinery of average size at 97 percent of capacity as opposed to 87 percent? In essence the refining operation (although flexible in its output potential and therefore similar to manufacturing) is the processing of fluids under pressure. Refinery configuration usually requires fairly extensive use of fixed plant and operating personnel throughout normal production ranges. Therefore it follows that once the basic crew is available and the refinery is on stream, relatively minor cost increases accompany increases in output. For this reason as capacity is approached, the marginal cost of additional output is extremely low when measured by the absolute additional cash outlay required. This fact has prompted major oil companies to "dump" significant quantities of refined product at low prices whenever their individual supply-demand situation produced a reduction of their "normal" sales. The action was justified on the grounds of marginal cost (incremental-barrel) pricing.

Discontinuities

Careful inspection of the situation discloses a misunderstanding of marginal-cost principles. Marginal cost is the cost generated by adding one additional unit in the production process. The misunderstanding takes place in the definition of the unit. James R. Nelson has edited a collection of essays pertaining to economic analysis for practical application of marginal-cost prices.[13]

Gabriel Dessus, in his essay, "The General Principles of Rate-fixing in Public Utilities," presents a classic example that bears directly on the refinery problem.[14] His example involves a French train. However, destinations within the United States are easier to visualize. Assume that a passenger train runs from Tulsa to Chicago. With the present energy shortages, more and more people may decide to use the means of travel that appears more certain, and therefore move from automotive travel to the passenger train. The director of Amtrak requests a marginal cost study to

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[13]J. R. Nelson, Marginal Cost Pricing in Practice (Englewood Cliffs: Prentice Hall Inc., 1964).

[14]Ibid., p. 42.

determine the additional cost involved in carrying these added passengers. Assuming a coach on the Amtrak system will accommodate ninety persons and the last available coach is half full, compute the marginal cost for the next fifty passengers.

The approach that is most tempting to the uninitiated is to determine the cost of the additional diesel fuel to be consumed by the engine when required to pull the weight of an average person down the track at the required speed.

This approach appears to work well until the forty-sixth additional passenger is reached at which time there is a discontinuity and a whole new coach must be added. Obviously, one would never add an entire coach to provide service for one person (although the rail industry has repeatedly contended that the government has not been adequately concerned with the diseconomies involved in carrying only a few passengers). However, rational individuals outside government control have added new coaches when relatively few passengers were guaranteed at the inception of the service. Clearly, in these circumstances, ultimate utilization of the new facilities at optimum levels was envisioned from the outset. What is the marginal cost of the forty-sixth through the fiftieth passenger, and what was the marginal cost of the ninetieth passenger on the previous coach? The problem is immediately simplified if one remembers that one is adding and computing marginal costs on units of added capacity, not on individual passengers. The marginal cost of adding another coach may, therefore, be easily calculated. To obtain the marginal cost for an individual passenger, Dessus carefully explains that one has to use the average marginal cost for a new coach plus the operating costs of transporting the passenger.

Dessus is not alone in his observation. Marcel Boiteux presents three general conclusions which relate to similar situations in an essay entitled "Marginal Cost Pricing":

1. Sale at marginal cost involves deficits when the firm is overequipped relative to demand but it is profitable when the enterprise is very underequipped.[15]

2. When capacity is optimum, sale at marginal cost of the service rendered by the marginal plant exactly covers the costs of this marginal equipment.[16]

3. Sales tariffs based on marginal costs should be established with reference to continuously optimum plant sizes, regardless of the actual successive phases of over- and under-capacity through which the enterprise passes.[17]

It is quite clear that these writers believe that whenever discontinuities in productive capacity exist, the marginal cost associated with the last unit of existing capacity produced is the average marginal cost for the existing plant size; and the marginal cost of the first unit of production

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[15]Ibid., p. 55. [16]Ibid., p. 56.

[17]Ibid., p. 57.

from a new facility. Had refinery managers been willing to accept this theory, product dumping might have been avoided or reduced during periods when a major oil company's refining volume and normal refinery sales were out of balance even though domestic demand exceeded domestic refinery output.

Financial Implications

What are the financial consequences of not understanding this concept? The approach to marginal costing based on a fraction of an additional productive unit when discontinuities exist will erode capital (through a series of losses). If one concludes by his analysis that the cost for the forty-sixth additional passenger from Tulsa to Chicago is, for example, 0.1 cent per mile and prices his tickets accordingly, he might soon fill the coach; however, he would have extreme difficulty showing a long run profit. Financiers, observing his actions, would be reluctant to lend him additional capital for his next coach. Why should the refining industry be different? Some financial people feel it is not.

> Why then do so many cling to the belief that somehow they can have their essential needs satisfied without paying all the associated costs? There is also the companion belief that at least part of the burden of costs can be avoided by shifting it to others. ... To a major degree, beliefs such as these have contributed to the critical shortage of energy now existing in the United States. They have effectively restricted both the generation and the investment of capital funds needed to provide an adequate supply of energy. ... It ought to be

> obvious that the energy industries can't invest enough if the money isn't available and the money won't be available if profits aren't adequate. Profits, of course, can't possibly be adequate if the price paid for energy by consumers is too low.[18]

The oil companies' economic lesson was not accepted. Independent marketers made substantial inroads in the major oil companies' markets using available low-cost product from independent refineries. The accompanying reduction of "branded sales" caused the refineries to have momentary surpluses despite the fact that there were no great surpluses for the economy as a whole. Normal distribution channels being full, the refiners proceeded to dispose of this temporary surplus in the only areas where excess demand existed (the cut-rate market). These sales were at low prices and provided cut-rate marketers with additional "fuel for the fire" to again invade the major marketing area and capture even more branded sales. This shift again created a temporary surplus situation, and the process which created the economic instability for any one individual major oil company continued. Had the major oil companies realized the true marginal cost of the products dumped, they undoubtedly would have considered reducing production whenever they lost branded sales volume.

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[18]John G. Winger, "Something For Nothing" The Petroleum Situation, November 30, 1973, p. 2.

SUMMARY OF ECONOMIC CONSIDERATIONS

The refining industry, although structured as an oligopoly, does not appear (during the period studied) to conform in detail to any of the theoretical models advanced for oligopolies. This lack of conformity seems to be due to United States Government interference in the market picture, and a lack of acceptance by refinery executives of marginal cost principles as they relate to firms with discontinuities in productive capacity. The United States Government's concerted effort to ensure survival of marginal refineries has taken several forms as further detailed in Chapter 4. These forms include an outright gift which reduced input costs (import allowables), noncompetitive bidding practices (back in options available to small refiners on jet-fuel contracts), and a semi-guaranteed crude supply (government takes royalty oil in kind and delivers to small refineries). The government-protected position of small refiners has enabled some of them to supply cut-rate marketers with the initial potential for invading major marketing territory. After the first inroads were successful, supply was maintained by the majors themselves due to a misapplication of marginal cost pricing.

Modified views of the economic structure of the industry were presented. The first followed the Sweezy model but severely reduced the slope of the inelastic demand curve to reflect an attitude change as discussed on page 49.

This attitude change, coupled with government reduction of small refinery costs, could have induced some refiners to believe that their marginal costs were below the vertical portion of the marginal revenue curve and thus induced them to continue price-cutting activity. The second modification was an attempt to explain industry activity in general, rather than industry activity from the view of the cut-rate refiner. For a time the government succeeded in controlling price leadership. The government effectively used the import program to hold existing prices and to foster price competition by independents, thus imposing upward rigidities on price and at the same time removing "natural" downward rigidities of the oligopoly structure in the industry.

In reaction to this government involvement, prices appeared to have a fluctuating downward movement during the early 1960's as indicated on page 79, Figure 4.1. Costs, however, have continued to rise and seem to have imposed a floor under prices in the mid to latter portion of the 1960's. A modification of a model presented by White, Market, and Taylor, which itself is a modification of a Lanzillotti model, seems to explain in an ex post fashion the activity of the industry during this period of intense government intervention in the marketing process. The new model (modified by the author, but agreed with by economists in the companies contacted), demonstrates the suppressive price associated with the major oil companies' loss of product discrimination, the government's assistance of independent refiners, and artificial competitive prices in certain areas. Price suppression was intensified by the refiners' desire to operate at fairly constant volumes. This desire was fortified by erroneous marginal cost studies. Low price then became a constraint in the model due to the activity of congressional investigating committees and government pronouncements concerning potential elimination of the crude-oil import program.

Recent large increases in the cost of crude oil associated with the Organization of Petroleum Exporting Countries' cartel has effectively removed most of the government market-interfering mechanisms previously mentioned and thus provides the terminal date for this research. It is interesting to note that the regulatory policies since that time have accomplished similar purposes. The price-control program established different prices for "new" and "old" oil. Realizing that different firms have different combinations of new and old oil, cost differences again reflect themselves in price differences at the pump. The author does not attempt a current analysis in this paper but rather limits his work to a historical review of cause and effect.

The basic refining operation and the economic structure of the industry are both complex. The accounting and economic frameworks which explain cost allocation and firm behavior are also reasonably complex. Determining the best sequence for the presentation of material was made difficult by these complexities since all areas really should be considered together to obtain the best view of refinery operations. For this reason the last two chapters which contain the accounting and economic frameworks should be referred to when considering the competitive forces in the petroleum-refining industry and the price restraints presented in the next chapter.

Chapter 4

FACTORS AFFECTING PRICE FLEXIBILITY IN THE REFINING INDUSTRY

INTRODUCTION

The complex structure of competitive forces in the petroleum-refining industry is examined in this chapter. Prices of petroleum products are analyzed to determine whether the price trends suggest the presence of excessive restraints on price structure. A brief review of the "competitive products" which vie with components of the product mix is also presented.

Several indirect competitive forces are examined separately to explore the extent of apparent artificial restraints affecting price. Preliminary study by the author appeared to support the hypothesis that prices of standard refined products were semirigid (lacking upward flexibility) for a period. Observable direct restrictions of price are also studied.

The following research questions are being probed in this chapter.

1. Do empirical data indicate the presence of price-suppressive activity in the price structure of the petroleum-refining industry?

2. What are the competitive forces in the petroleum-

refining industry?

3. What role has the rigidity of policy played in price structure?

4. Has the government's involvement in the refined-products marketing process produced upward rigidity in the price structure?

5. What effect has monopoly pricing practice had on refined-product prices?

6. Did the petroleum-refining policies or practices add to the upward rigidity of product pricing?

7. What was the short-run effect of ecological considerations?

8. Have the price rigidities demonstrated in this chapter retarded financial investment?

These questions present a framework for logical inquiry into the complex question of price rigidities. Each question was designed to explore a potential price-suppressive activity or influence.

REFINERY PRICE TRENDS

Oklahoma refinery prices are examined in this study for two reasons. First, oil-producing areas historically had more flexible price structures than nonproducing areas due to the ease of entry afforded independent refiners by the close proximity of raw materials. In addition, smaller firms were available within the Oklahoma area. Although prices from a limited geographical area (the Oklahoma pricing area) were used, the remainder of the study included representation from all domestic areas and the conclusions are not restricted to the Oklahoma pricing area.

Table 4.1 and Figure 4.1 present the average Oklahoma refinery prices of regular-grade gasoline from January 1953 to December 1972. A brief glance at the raw price data allows several observations. Prices of regular gasoline exhibited a gradual upward trend from 1954 to early 1959. Seasonal fluctuations occurred from early 1959 to late 1964. A period of stable but lower prices ensued. No evidence of the seasonal cycle can be observed from October 1965 to October 1967. Prices were lowered even further during 1968 and 1969. A 92-octane product stabilized at the approximate price of the 89-octane product when this latter product was first introduced; then, the higher-octane product was further lowered in price. A detailed analysis of the data should shed further light on these prices.

The inflationary trend of the period under observation is common knowledge, but the wholesale refined-products prices do not seem to follow this trend. A statistical test (t) was applied to the price data to obtain an indication of the significance of this observation.

The average Oklahoma refinery prices of regular-grade gasoline and the wholesale price index (all commodities) are presented in Table 4.1 and 4.2 respectively. The null hypothesis states that the difference in slope between the least-squares regression lines computed from "common size" or comparable percentage data for both gasoline prices and the wholesale price index is equal to zero. This hypothesis is tested in Appendix B

Table 4.1

Average Oklahoma Refinery Prices
of Regular Grade Gasoline
1953 - 1972

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1953	10.50	10.50	10.50	10.50	10.50	10.93	11.50	11.50	11.50	11.50	11.47	11.36	11.02
1954	11.22	11.10	11.06	11.06	11.06	11.06	10.88	10.81	10.81	10.81	10.81	10.81	10.96
1955	10.81	10.81	10.81	10.87	11.00	11.00	11.03	11.25	11.25	11.25	11.25	11.25	11.05
1956	11.25	11.25	11.33	11.38	11.73	11.88	11.88	11.88	11.88	11.76	11.63	11.63	11.62
1957	12.27	12.63	12.63	12.63	12.63	12.41	12.01	12.00	12.11	12.13	12.13	12.13	12.31
1958	12.38	12.28	12.15	12.00	12.00	12.25	12.57	12.88	12.88	12.76	12.50	12.50	12.43
1959	12.48	12.38	12.57	12.75	12.63	12.32	12.08	12.62	12.55	12.00	11.86	11.56	12.32
1960	11.15	11.34	11.82	12.00	11.60	12.17	12.73	13.30	13.38	13.38	13.38	13.38	12.47
1961	13.38	13.38	13.38	13.38	12.99	13.13	13.13	12.92	11.88	11.88	12.00	12.22	12.80
1962	12.34	11.26	10.84	12.64	12.91	13.00	13.00	13.00	13.00	13.00	13.00	12.77	12,56
1963	12.10	11.64	12.00	12.48	12.75	13.06	12.94	12.19	11.80	12.23	11.00	11.57	12.15
1964	11.63	11.63	11.51	11.41	11.63	11.63	11.63	11.63	10.83	11.31	12.04	12.25	11.59
1965	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.08	11.95	12.25	12.25	12.25	12.21
1966	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25
1967	12.25	12.37	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.52	12.38
1968	11.33	11.59	11.90	11.99	11.62	11.88	11.88	11.88	11.88	11.69	11.63	11.64	11.73
1969	11.77	11.75	12.48	12.44	12.29	12.22	12.09	12.28	12.18	12.17	12.25	12.29	12.18
1970	12.10	12.09	12.00	12.69	12.67	12.54	12.70	12.71	12.66	12.66	12.73	13.24	12.56
1971	13.16	12.95	12.80	12.49	13.13	12.98	12.88	12.88	12.81	12.75	12.75	12.75	12.86
1972	12.73	12.62	12.67	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.82

Source:

Minerals Yearbook, United States Department of Interior, 1953 to 1972.

Platt's Oil Price Handbook, 1953 to 1972.

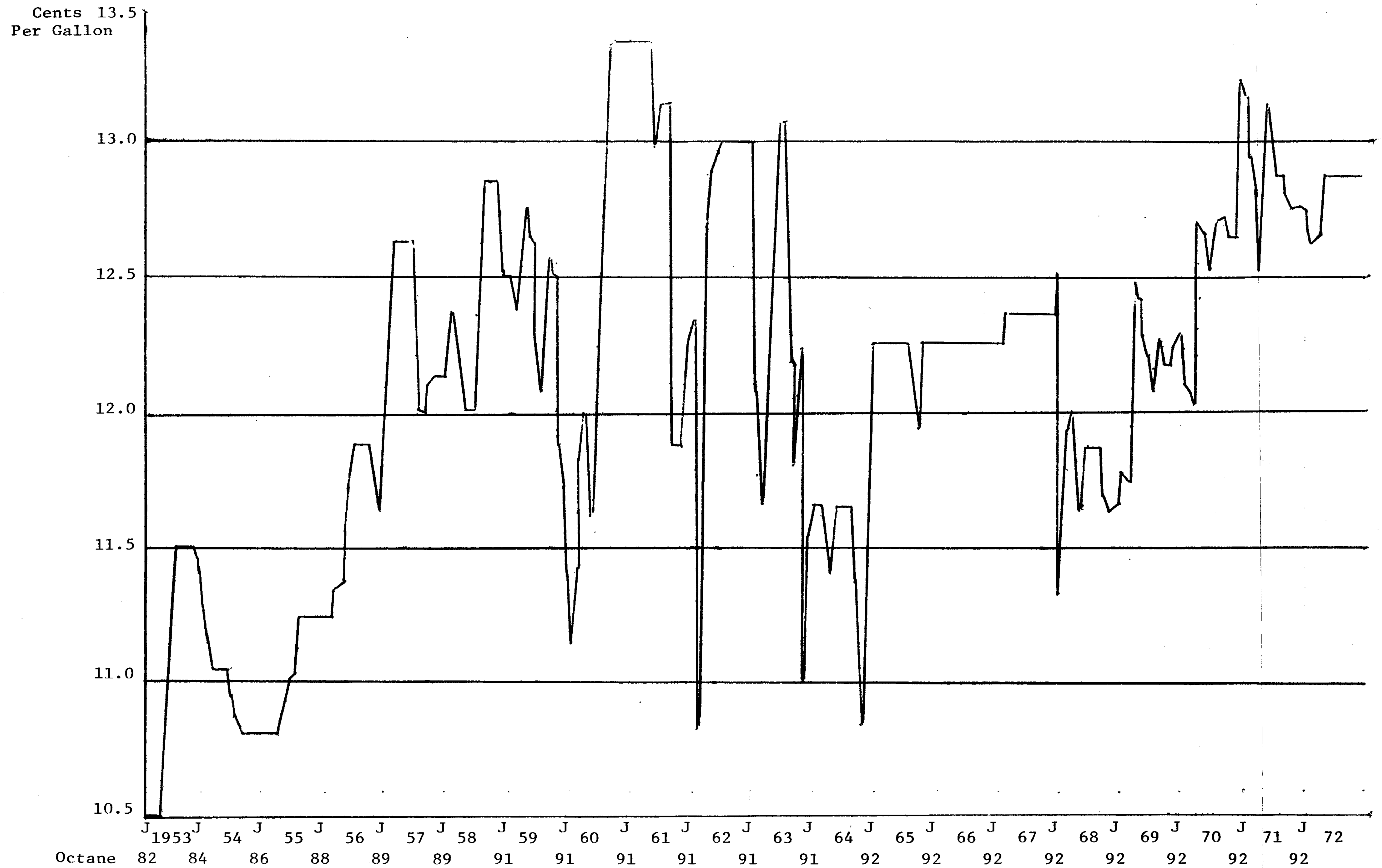

Figure 4.1

Average Oklahoma Refinery Prices and Octane Ratings
for Regular-Grade Gasoline

Source: Table 4.1

Table 4.2

Wholesale Prices United States
Department of Labor Indexes
All Commodities
1953 - 1972

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1953	109.9*	109.6	110.0	109.4	109.8	109.5	110.9	110.6	111.0	110.2	109.8	110.1
1954	110.2	110.5	110.5	111.0	110.9	110.0	110.4	110.5	110.0	109.7	110.0	109.5
1955	110.1	110.4	110.0	110.5	109.9	110.3	110.5	110.9	111.7	111.6	111.2	111.3
1956	111.9	112.4	112.8	113.6	114.4	114.2	114.0	114.7	115.5	115.6	115.9	116.3
1957	116.9	117.0	116.9	117.2	117.1	117.4	118.2	118.4	118.0	117.8	118.1	118.5
1958	118.9	119.0	119.7	119.3	119.5	119.2	119.2	119.1	119.1	119.0	119.2	119.2
1959	119.5	119.5	119.6	120.0	119.9	119.7	119.5	119.1	119.7	119.1	118.9	118.9
1960	119.3	119.3	120.0	120.0	119.7	119.5	119.7	119.2	119.2	119.6	119.6	119.5
1961	119.9	101.0†	101.0	100.5	100.0	99.5	99.9	100.1	100.1	100.0	100.0	100.4
1962	100.8	100.7	100.7	100.4	100.2	100.0	100.4	100.5	101.2	100.6	100.7	100.4
1963	100.5	100.2	99.9	99.7	100.0	100.3	100.6	100.4	100.3	100.5	100.7	100.3
1964	101.0	100.5	100.4	100.3	100.1	100.0	100.4	100.3	100.7	100.8	100.7	100.7
1965	101.0	101.2	101.3	101.7	102.1	102.8	102.9	102.9	103.0	103.1	103.5	104.1
1966	104.6	105.4	105.4	105.5	105.6	105.7	106.4	106.8	106.8	106.2	105.9	105.9
1967	106.2	106.0	105.7	105.3	105.8	106.3	106.5	106.1	106.2	106.1	106.2	106.8
1968	107.2	108.0	108.2	108.3	108.5	108.7	109.1	108.7	109.1	109.1	109.6	109.8
1969	110.7	111.1	111.7	111.9	112.8	113.2	113.3	113.4	113.6	114.0	114.7	108.5Δ
1970	109.3	109.7	109.9	109.9	110.1	110.3	110.9	110.5	111.0	111.0	110.9	111.0
1971	111.8	112.8	113.0	113.3	113.8	114.3	114.6	114.5	114.4	114.4	114.5	115.4
1972	116.3	117.3	117.4	117.5	118.2	118.8	119.7	119.9	120.2	120.0	120.7	122.9

*1947 - 1949 = 100%

†1957 - 1959 = 100%

Δ1967 = 100%

Source:

Survey of Current Business -monthly issues from 1953 to 1972.

using a t test (see page 171).

A graphic portrayal of the comparable data is given in Figure 4.2. This graph depicts average Oklahoma wholesale prices for regular-grade gasoline as a percentage of the first month's reported prices, as well as the Bureau of Labor Statistics wholesale price index (all commodities) as a percentage of the first month's reported index value.

A period of fairly stable wholesale price levels was indicated from early 1958 to the end of 1964 when the current inflationary trend appears to have begun. For this reason the data were divided into two groups, pre-1965 and post-1964. This division also closely approximates the point in time when the average gasoline prices no longer exceeded the wholesale price index, when each is considered as a percentage of its respective base month value.

In Figure 4.3, least-squares regression lines were superimposed on the data originally represented in Figure 4.2. Two separate t tests of regression-line slopes were calculated and presented in Appendix B to determine whether price-level adjustments were appropriate. The results of the first test indicated that price-level adjustments may have been appropriate for the pre-1965 period (the null hypothesis could not be rejected). However, the second test indicated that the null hypothesis should be rejected at the 99 percent confidence level for the post-1965 period. Therefore, price-level adjustments were made for neither period since a partial use of price-level adjustments would

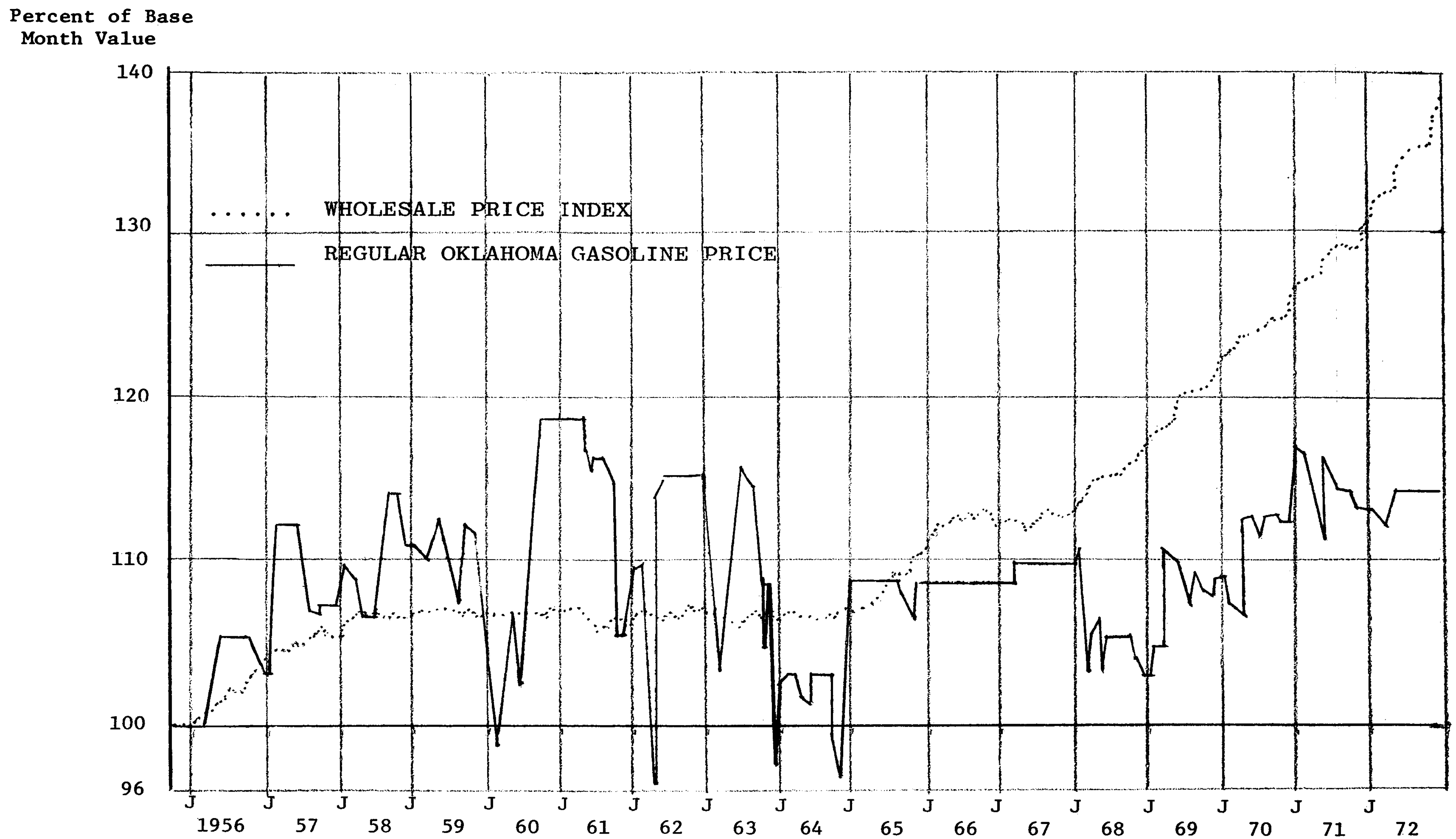

Figure 4.2

A Common Size Comparison of Regular Oklahoma Gasoline Prices with the Wholesale Price Index (Each Expressed as a Percentage of its Relative Base Month Value)

Source:

Data taken from Tables 4.1, 4.2, B.2, B.3, B.8, B.9.

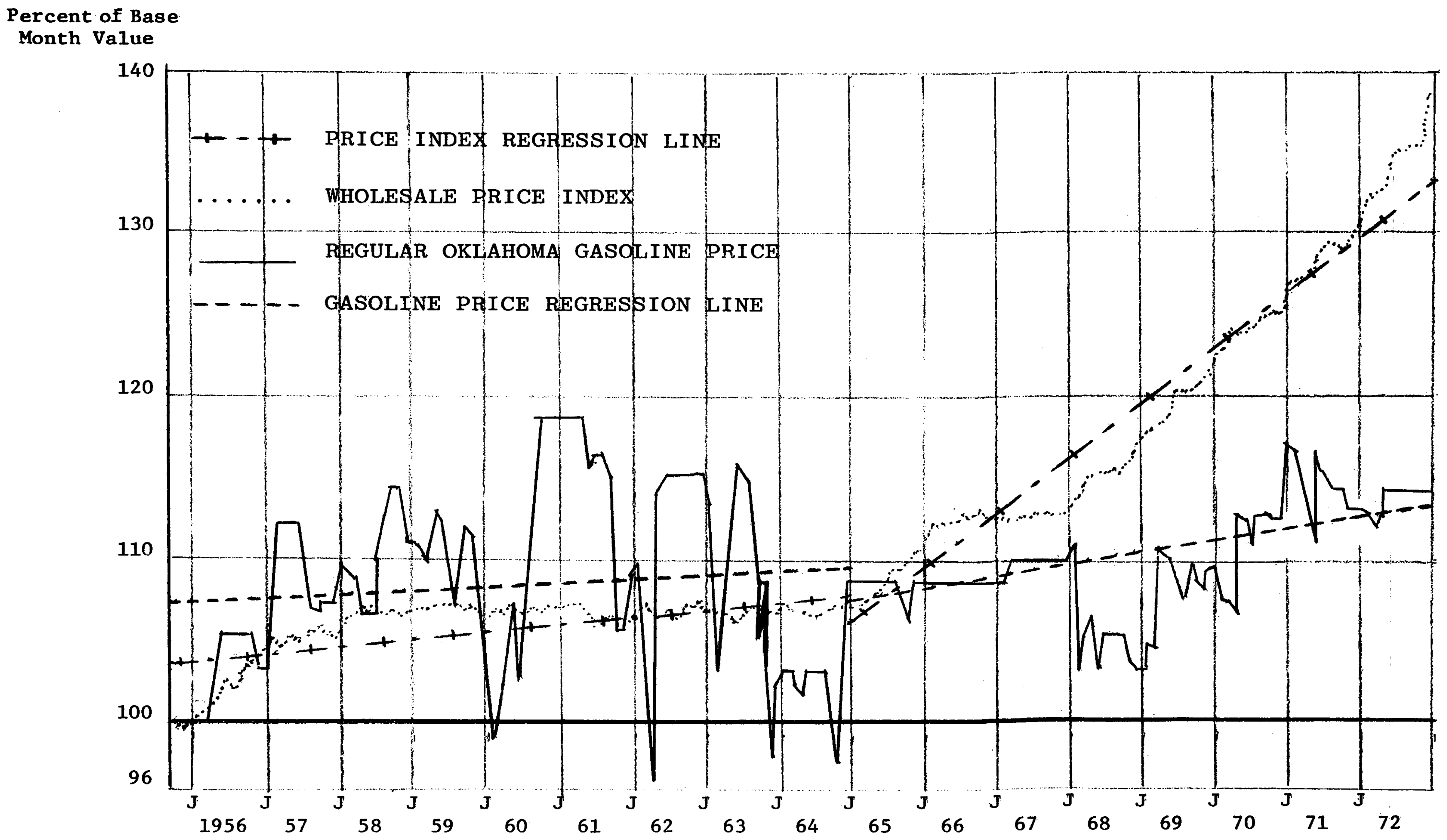

Figure 4.3

A Comparison of Least-Squares Regression-Line Slopes
Fitted to Common-Size Gasoline Prices
and Wholesale Price Index Values

Source:

Data taken from Tables 4.1, 4.2, B.2, B.3, B.8, B.9.

be inconsistent. Hesitancy in using price level adjustments in the pre-1965 time period also seemed appropriate because the wide fluctuations in gasoline prices produced an extremely low coefficient of correlation for that regression line (.110752). A search for the cause for the change which occurred in the relationship between wholesale gasoline prices and the wholesale price-level index seemed desirable to the author.

An observation of the original wholesale gasoline prices suggested the introduction of a seasonal price depressor in 1959. Significantly the oil-import program was adjusted by Presidential Proclamation 3279 on March 10, 1959, and subsequently contained price-depressive factors which are detailed on page 100. Another t test of regression line slopes was applied to the price trend for regular grade gasoline prices before and after this change in import policy. Allowing for a delay in reaction to the announcement of March 10, 1959, to reflect its seasonal trend, the one-year period eliminated runs from September, 1959 to August, 1960 inclusively. Although this period was eliminated for the reasons given, an examination of Figure 4.1 will reveal the fact that the first severe seasonal depression of price occurred in this period. This one-year period was omitted for two reasons; first, to eliminate the uncertain period of transition associated with the policy change, and in addition, to avoid any seasonal difference by ensuring that the two time periods cover the same months of the year.

The t test of regression-line slopes clearly indicates the rejection of the null hypothesis at the 99 percent confidence level (see Appendix B beginning on page 171). This fact would strongly imply that the two sets of data were not taken from the same population; yet the participants in the Oklahoma market for wholesale gasoline prices did not change materially over the nine-year period encompassed by the test. The conclusion must be reached that there has been a significant change in market conditions. Since total demand was increasing over this time frame and the reduced prices were not in the best interest of the oligopoly structure within the industry, the primary cause appears to be external to the petroleum refining industry. The oil-import program initiated in March, 1959, provides a logical explanation of the price trend change. Prior to this change, prices were increasing, but after the program was initiated an abrupt reversal took place and prices decreased. The fact that octane increased during this period makes the price-trend reversal even more significant. The effects of the import program on wholesale gasoline prices are discussed in detail on page 100.

COMPETITIVE FORCES IN THE PETROLEUM-REFINING INDUSTRY

Many forces help to shape the price structure for the refining industry. Before it is possible to appreciate these competitive forces, a brief look at the products produced by a refinery is required.

A relatively complete technical breakdown of refinery products is presented in Figure 4.4; however, the analysis of competitive forces in this study is confined to the standard products normally produced in volume. Only completed products normally sold outside the industry will be considered. The inclusion of gas oils and petrochemicals could add to the complexity of the analysis without contributing significantly to the conclusions.

The basic refinery process in its simplest form is the heating of crude oil in a still, and the recovery of the gases and oils that result at different temperatures. The lighter fractions evaporate at lower temperatures, the heavier fractions at higher temperatures. There are three natural groupings of these products; the residues, the distillates, and the gasolines.

The Residues

The residues are, in essence, the portion of the barrel that remains in the "bottom" when the distillation process is completed. Traditionally three major products have been made from the bottom of the barrel. Residual fuel oil is the most natural of the three; however, with additional processing, asphalt or coke can be made from the same residue material. The ability to make the two latter products is primarily dependent upon refinery configuration.

NATURAL GAS

Natural gas

Gas oil

Refinery gases

CRUDE OIL

Light distillates

Middle distillates

Heavy distillates

Residues

Refinery sludges

Noncondensable

Liquefied

Processed derivatives

Gasoline

Refined oils

Gas oils

Absorber oils

White oils

Saturating oils

Emulsifying oils

Electrical oils

Paraffin Waxes

Light lubricating oils

Intermediate lubricating oils

Heavy lubricating oils

Petrolatum

Residual fuel oils

Asphalts

Coke

Acid coke

Sulfonic acids

Heavy fuel oils

Hydrogen

Light hydrocarbons

Carbon black

Light naphthas

Intermediate naphthas

Heavy naphthas

Kerosine

Signal oil

Technical oils

Medicinal oils

Saturating and insulating waxes

Fatty acids

Fatty alcohols and sulfates

Medicinal

Technical

Liquid asphalts, binders, and fluxes

Steam-reduced asphalts

Oxidized asphalts

Domestic and industrial fuels
Crude oil production stimulus
Raw materials for synthetic hydrocarbon chemicals
Production of carbon black
Component of automotive and aviation fuels
Liquefied gases, domestic and industrial fuels, and illuminants
Raw material for synthetic hydrocarbon chemicals
Metal cutting and glass manufacture
Welding, refinery fuel, and regrigerant
Rubber tires, inks and paints
Cooking and heating — Synthetic motor fuels
Synthetic rubbers
Lubricating-oil additives
Aviation gasoline blending agents
Antifreeze, fat, lacquer, and drug solvents
Gas-machine gasoline
Automobile gasoline — Aviation gasoline
Commerical solvents
Explosives
Blending naphthas
Raw material for synthetic hydrocarbon chemicals
Varnishmaker's and painter's naptha
Dyer's and cleaner's naphtha
Turpentine substitutes
Cattle and insect sprays
Jet, stove, lamp, and tractor fuels
Railroad signals, lighthouse oil, and ship illuminants
Lubricating-oil additives — Carburetor oils
Soaps
Naphthenic acids
Metallurgical, domestic heating, Diesel-engine and light industrial fuels
Gasoline recovery oil and benzol recovery oil
Insecticides and tree sprays
Bakers, fruit packers, candy makers, egg packer's and slab oils
Recoil oils and hydraulic oils
Salves, ointments, and creams — Cosmetics
Internal lubricants
Wood, leather, and twine oils
Cutting, paper, leather, and textile oils
Switch, transformer, and metal-recovery oils
Candy and chewing gum wax
Candle, laundry, sealing, and etcher's wax
Paper, match, and cardboard wax
Medicinal wax — Canning wax
Synthetic lubricants and their derivatives
Grease and soap — Lubricants
Rubber compounding
Household detergents and wetting agents
Spindle, turbine, transformer, and compressor oils
Household lubricating oils
Ice-machine, meter, dust-laying, and tempering oils
Journal, motor, Diesel-engine, aircraft, and railroad oils
Steam-cylinder, valve, transmission, and printing ink oils
Black oils — Tempering oils
Cup, switch, automotive, industrial, and cable grease
Cosmetics
Salves, creams, ointments, and petroleum jelly
Rust preventatives, rubber softeners, lubricants, and cable coating compounds
Wood preservation and gas manufacturing oils
Metallurgical oils
Marine boiler fuel — Railroad boiler fuel
Roofing and shoe material
Shingle and paper saturants
Road oils — Emulsion bases
Briquetting and paving asphalts
Paint bases — Flooring saturants
Roof coatings and waterproofings
Rubber substitutes — Insulating asphalts
Carbon electrodes — Carbon brushes
Fuel coke
Metallurgical coke
Fuel
Saponification agents — Fat splitting agents
Emulsifying agents — Demulsifying agents
Refinery fuel

Figure 4.4

Petroleum-Refinery Products

Source:

Collier's Encyclopedia, Vol. 18, 1972, p. 632.

The economics of residual production must therefore be considered before the refinery is built.

For many years residual fuel oil was placed in competition with a very inexpensive coal in the European market. Since Europeans used substantial quantities of residual fuel, the low price of coal acted as a natural competitive ceiling for the price of residual fuel in world markets. The production of residual fuel in the United States was comparatively uneconomical at this low price, and few companies produced it. Most United States companies, when faced with the original-investment problem, designed their refineries to produce asphalt or coke.[1] Since their introduction, the revenue from the latter two products has traditionally exceeded the revenue from the production of residual fuel oil. One of the primary reasons for this was the government's policy regarding fuel-oil importation.

Whenever surges in residual fuel-oil consumption tended to increase price, the government traditionally intervened. Import barriers were lifted and enough additional fuel oil was imported to maintain the previous low price. Large and repeated demands for additional fuel oil have occurred within recent years. Standards imposed to control sulfur emissions had, temporarily, directed public

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[1]One major oil company did not follow this trend because of a heavy utilization of thermal crackers rather than catalytic crackers.

utilities away from the use of most domestic coal and toward either residual fuel oil or gas during the latter part of the period under observation.

If the supply of input factors is held constant for any reason, then, under normal circumstances (regular market forces at work) large increases in consumption would be reflected in gradually increasing prices. These price increases would generate economic profit and would normally attract additional investment to produce products in short supply. Existing refineries, designed to produce coke or asphalt, would undoubtedly continue to follow their design configuration and produce those products. The increased demand would create a more difficult choice among the residue products that could be produced by new refineries. If demand persisted, and prices continued to rise, more and more new refineries would decide to produce residual fuel oil. This sustained increase in demand and production would cause the price of the other two competing products to go up only slightly while the fuel-oil price would stabilize at a considerably higher level. The government's activity prevented such a solution to the problem, as indicated by the prices presented in Table 4.3. The price of residual fuel from 1953 through 1972 has remained a relatively low percentage of the price of a barrel of crude. This low price is particularly significant when viewed from the engineer's volume-oriented viewpoint. Operating personnel frequently speak of selling a barrel of residual fuel oil

Table 4.3

Average Oklahoma Refinery Prices
of Residual No. 6 Fuel Oil
1953 - 1972

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1953	1.03	1.01	1.00	1.00	1.00	1.10	1.19	1.20	1.21	1.26	1.37	1.49	1.15
1954	1.54	1.51	1.39	1.27	1.21	1.12	1.08	1.15	1.20	1.34	1.42	1.47	1.31
1955	1.57	1.58	1.59	1.65	1.79	1.83	1.83	1.83	1.83	1.83	1.83	1.96	1.74
1956	2.14	2.15	2.12	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.14	2.39	2.14
1957	2.60	2.64	2.52	2.48	2.48	2.41	2.26	2.10	2.03	1.90	1.80	1.80	2.25
1958	2.03	1.88	1.68	1.71	1.73	1.73	1.64	1.59	1.60	1.13	1.73	1.83	1.73
1959	2.02	2.18	2.15	1.94	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.93	1.97
1960	1.93	1.99	1.83	1.75	1.75	1.87	1.95	1.95	1.95	1.95	1.95	1.95	1.89
1961	1.95	1.95	1.95	1.89	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.88
1962	1.86	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
1963	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
1964	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	2.03	1.96
1965	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.06	2.15	2.15	2.15	2.08
1966	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
1967	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
1968	1.70	1.70	1.70	1.70	1.70	1.68	1.65	1.65	1.65	1.65	1.65	1.65	1.67
1969	1.74	1.78	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.71
1970	1.83	2.00	2.00	2.00	2.00	2.26	2.55	2.71	2.73	2.73	2.73	2.73	2.35
1971	2.68	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.61
1972	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60

Sources:

Minerals Yearbook, U.S. Department of Interior, 1953 to 1972.

Platt's Oil Price Handbook, 1953 to 1972.

for less than what was paid for it (i.e., for less than the cost of the barrel of crude), although this concept is inaccurate from an economic or an accounting view.

A sudden shift in consumption would require sudden and drastic changes in refinery output even if "free" market forces were at work. With government intervention (an attempt to maintain a low-cost energy policy) the adjustment becomes even more severe. The adjustment from almost total dependence upon foreign sources (95 percent of eastern requirements) to self-sufficiency would be a violent one. The author indicated in Chapter 1 that if the basic hypothesis were true and there were rigidities in the price structure, sudden violent adjustments would be expected since normal market forces, which have a tendency to smooth adjustments by giving lead indicators in the form of price changes, would be absent. Without this lead indicator the industry must perforce read minds. No difficulty exists in the observation of increases in demand; but, since prices under controlled conditions do not reflect increased demand, it is necessary to anticipate or predict policy changes. Whether these changes in policy are made by our own government or by foreign powers, they may cause severe, abrupt changes in the refinery-product mix requirements or refinery-operating levels, or both.

Lack of capcity, coupled with a lack of input crude, caused the government to announce an abrupt policy change. The clear-air regulations were relaxed so that electric utilities converting from coal to residual fuel oil and gas were to stop the conversion, or possibly reverse it, and to operate with coal. Again, the serious difficulty observable in sudden policy change was the lack of a lead indicator. Coal companies had been closing down their operations over a period of years due to the restrictive high sulfur content of their product and the relatively low price of natural gas and residual fuel oil. They were not prepared to handle this sudden large increase in volume. Both industries will probably exert great efforts to meet the emergency, but an easy, long-run solution is not expected.

Newspaper headlines in the winter of 1970-1971 concerning shortages of residual oil first aroused the writer's interest in this topic. A careful discussion with refiners at that time disclosed no real shortage. There was only a shortage at the existing price. Refiners could have supplied additional fuel oil then, had there been an economic incentive. The government, however, following its regular policy, met this first public indication of a serious problem by increasing fuel-oil-import quotas.

The United States oil industry is producing substantial quantities of fuel oil. However, the majority of the companies are producing fuel oil at their foreign refineries. These refineries, although often owned and operated by domestic oil companies, are under the control of the governments of the countries in which the physical facilities exist. This foreign control of residual fuel oil became critical when the Organization of Petroleum Exporting Countries exerted extreme pressure on Canada, Japan, and most of the countries in Europe and Asia (by threatening to withhold all crude oil deliveries to prevent petroleum products refined in their countries from entering the United States).

The low price previously prevailing in the residual-fuel-market also controlled the selection of refinery location for residual-fuel-oil production. Relatively low labor costs had to be obtained in order for production of residual fuel to be economically attractive. The ability to import foreign crude also entered into the decisions, as will be discussed more fully in conjunction with the gasoline section of this chapter (beginning on page 99). In simplest terms, the crude-oil import policies basically allowed the importation of crude oil as a percentage of existing refinery capacity, and consequently, discouraged any attempt to increase refinery size where the total refinery input depended upon imported crude.

Discussions with industry personnel revealed that tentative contract proposals were made during 1973 which were more than double the government's normalized residual fuel-oil prices of prior years. As indicated in Chapter 2, such a move causes violent cost adjustments under the price-relative accounting allocation method. In addition, it should induce new construction to prepare for fuel-oil production. However, for reasons to be discussed under the financial-incentives section of this chapter (beginning on page 120), refineries were not built to meet this fuel oil requirement.

The Distillates

The middle-range group of products (called distillates) include kerosine, jet fuel, furnace distillate (number 2 fuel oil), and diesel fuel. Due to the flexibility of the manufacturing operation within this range of products, an overriding consideration at each level is the cost of recycling to upgrade the product. This recycling and upgrading potential is particularly prevalent in the inferior distillates (number 2 and number 3 fuel oil). Kerosine is in competition with jet fuel because of their similar composition. Furnace distillate competes with natural gas and electricity because of their similarity of use. These inferior distillates also compete with jet fuel, but to a lesser degree.

Jet fuel. A little-known policy adopted by the government affects the allocation of military jet-fuel contracts. The "small-business set-aside program" enables small refiners to compete in the production of jet fuel.[2]

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[2]Armed Services Procurement Regulation, Paragraph 1-706.1 issued to conform to Title 10, Chapter 1137 - Armed Forces Procurement Generally, Section 2301 - Declaration of Policy.

Under this program a small refinery submits a bid along with the majors for a given volume of fuel at the small refiner's best price. When the bids are opened, if any major company has submitted a lower price, the small refiner is offered an opportunity to deliver the gallonage submitted in his bid at the major refiner's price. The major refiner is then allowed to supply only the remaining requirement. This set-aside program potentially involves up to 40 percent of the jet fuel delivered under any contract. This program is additional evidence that the government is keenly interested in providing artificial economies to the small refiners in an attempt to negate the effect of economies of scale and to promote price competition in the industry.

Furnace Distillate. The price of the furnace distillate has been held to an artificial low for two reasons. First and most important is that the price of natural gas has been held to an artificial low by the Federal Power Commission since 1954. Petroleum industry observers compare natural-gas inventory replacement cost to selling price and conclude that regulated prices are too low. This severe restriction of natural-gas price has been decried by the industry almost from its inception. Despite logical argument, the regulatory agency has persisted with the low-cost energy policy to the point that imported, liquefied products commanded a significantly higher price over a long period of time than the natural gas produced domestically.

This low price has discouraged search for additional gas reserves and has indirectly increased further the demand placed on refined products. The lack of available natural gas has caused utilities to increase their utilization of residual fuel. The lower price of the distillates has also caused refiners to search both for new methods to upgrade products and also new products to produce. This search for new products (which do not fall under the price restrictions covered in this section) has created a small crisis of its own. The raw material for the production of plastics was developed and rapidly grew in volume. With the recent shortage of total crude supply and refinery capacity, the plastics industry experienced critical shortages. The price of its raw material input had increased appreciably due to the scarcity of crude oil.

Further elaboration on this phase of the distillate-rigidity problem is probably unnecessary since the price of natural gas has received such widespread publicity. This portion of the problem, however, is grave and brevity of coverage should not diminish its significance. Most government officials will admit the impact of the low natural gas price upon available energy, and therefore, have agreed indirectly with the premise that this low price also has strong impact on furnace distillate prices.

Furnace distillates also compete with electrical energy in a lesser but significant way. Electrical utilities have successfully discriminated in their pricing scheme to produce at least four different price structures. Three of these are rather natural divisions of their sales. Reported statistics break down the sales to ultimate consumers into four catagories:

1. Industrial users.
2. Commercial users.
3. Residential users.
4. Other users.

For the purpose of this discussion, the "other users" category is disregarded since it is a catch-all and represents no clearly distinguishable segment of the electric utilities' marketing activity. Residential sales must be analyzed further and broken down into two clearly differentiated segments in order to obtain the four price structures referred to above. Residential users with permanent electrical heating (total electric homes) and residential users without permanent electrical heating compose the two segments. Once this breakdown is complete we have three areas of discriminatory prices over the normal residential rates.

Justification for price discrimination is twofold. First, large industrial users are given a favored price structure because of the basic economies achieved by delivering large quantities of electrical energy to a single location, and also as an inducement to provide jobs and attract residential and commercial users into an area to achieve economies of scale and enlarge the rate base.

Expressed in another way the distribution system is quite simple and direct and requires much smaller capital investment in the form of poles, lines, and the like. This logic is difficult to fault. Court cases have upheld the justification of a price differential based upon reduced cost of distribution. There is no attempt in this discussion to debate that point. The second justification for price discrimination is more subtle and may contain an error in logic when considered with the first. This justification states in essence that there is a marginal efficiency associated with the utilization of off-season productive capacity. If a facility is being used extensively during a particular season of the year and is partially idle at another season of the year, the cost of delivering electrical energy during the slack period is a marginal cost. Therefore, a marginal price which is lower than other prices during the same period may be justified.

The production reducing effect of this attempt by the electric utilities to equalize the peak between summer and winter and to expand the rate base has been an artificial low winter heating rate which has effectively competed with the furnace-distillate rate. This low winter rate has helped to hold the price of this segment of the refined products to an artificial low. Empirical evidence to support this view is presented in Appendix C, beginning on page 191.

Gasolines

Since gasoline is the only product which does not have a "competitive" substitute, all external pressure exerted against the price of gasoline must be created by providing an arbitrary artificial cost advantage to some firms. The pressure mounted against the oligopoly price structure in the gasoline market was both direct and indirect. The primary tool was the government import program. Prior to the late 1950's the United States had surplus crude production compared to domestic consumption. This situation allowed many small refineries to operate with a relatively low input crude cost. The major refiners, being integrated oil companies and having excess crude available, allowed independents to fulfill part of their refining requirements. During the 1950's, exploration and development of foreign crude sources created a worldwide surplus of crude. At the time the domestic crude surplus was fading into history, the relatively inexpensive oil had been found and produced.

At a time when leasing and drilling operations were becoming more expensive, forces were set in motion which tended to reduce the incentive for exploratory drilling. The low cost of natural gas allowed it to be a ready substitute for some petroleum products. Under the guise of conservation provisions, the producing states adopted strict regulations relating to the production of crude oil. These regulations would have been a conservation tool had they conformed more closely to engineering requirements for optimum output. Unfortunately, they also were used to assist in maintaining a high domestic crude-oil price by frequent adjustment in the production rates. These adjustments often had more to do with price than with the maintenance of reservoir pressures.

In March, 1959, the government adopted a mandatory import quota system which prevented the domestic price from falling to the world price and established a dual pricing structure for the industry. Immediately, benefit accrued to any organization that could obtain the cheaper imported crude (refer to Table 4.4). If all refineries had been treated equally, this problem would not have been too formidable; however, such was not the case. The bill establishing the import quota system provided for exceptions and immediately exceptions came into being. A number of companies were successful in establishing refineries in the Carribean area which depended almost totally on imported crude and which were exempt from the import quotas. When this activity was attempted in the New England States (with great promise of local political reward from a trust fund to be established out of the crude cost difference), the procedure was finally defeated and no further exceptions were granted. A differential treatment among the oil companies was established as an integral part of the import program. Several classifications of refinery size were identified and the smaller refiners were allowed a greater

Table 4.4

Value of the Crude Oil Import Quota

(The difference between the domestic and foreign price of crude oil per barrel)

Year	Margin per Barrel
1963	$ .87
1964	.78
1965	.85
1966	1.25
1967	1.25
1968	1.25
1969	1.25
1970	1.36
1971	.518
1972	.764

Source:

Withheld by request.

percentage of import relative to their total crude demand than the larger refiners based upon a step-scale reducing-percentage of import allocations (see Table 4.5).

With the implementation of this program, two artificial noncompetitive levers came into existence and affected the gasoline-pricing system. The more direct of the two was the use of implication and threat by political groups and administrations. These groups suggested complete elimination of the artificially created domestic price by removal of all import restrictions. This threat was used to force industry leaders or potential leaders to roll back price advances which had already been announced. In addition, Senate investigative committees were busy probing the possibility of returning to a true world price by eliminating both the import program and the state regulation of allowables. This lever, when applied, was quite effective and several price advances were rolled back during the last decade. The procedure received very little publicity as a tool to control price, but received substantial publicity in the form of political attacks on the industry.

The second lever was even more effective. There is strong indication that the petroleum industry can become inherently unstable with respect to its refinery pricing operations, as was discussed previously in Chapter 3. Any force which tends to upset the delicate balance between refining and major-brand marketing causes major companies to

Table 4.5

Oil Import Quota Allocation
As a Percent of Input
Increment

Increment of Prior Year Average B/D Refinery Input	1965 First Half	1965 Second Half	1966	1967	1968*	1969	1970	1971	1972	1973
0 - 10,000	17.0	18.0	18.0	20.0		19.5	19.5	19.5	21.7	21.9
10 - 30,000	11.6	11.9	11.4	11.4		11.0	11.0	11.0	13.0	13.0
30 -100,000	9.2	9.4	8.9	8.0		7.0	7.0	7.0	7.6	7.6
100,000+	5.53	5.64	5.26	4.28		3.0	3.0	3.0	3.8	3.8

*This data is not available from local sources.

Source:

Code of Federal Regulations, 32A, Chapter X, sections 10-11.

dump quantities of refined product on the discount market in an attempt to preserve the operating efficiency of the refinery. This situation is a distinct characteristic of refining and is not associated with other joint production operations.

The second lever moved to create the initial upset of otherwise carefully planned refining and marketing operations. In a true oligopoly rather stable prices usually exist among alternate suppliers. Many economic reasons are suggested for the stable price and one common economic analysis is that there is a kink in the demand curve. Under this theory, potential price discounters are dissuaded. They reason that any price reduction would be met by the competition, rendered virtually ineffective, and all parties would suffer from the lower prices. The economies of scale associated with the large refiners' operations would enable them to prevail in the long run and to virtually eliminate any price rebel they felt was not good for the industry. The inequality of imports relative to total operations between the small refiners and the majors under the import program is a carefully calculated plan which attempts to equate in part the economies of scale between the small firm and the large firm. In effect, this allows a marginal refiner to continue his otherwise unprofitable operation. Some small refineries have virtually existed on the import allocation margin. To be more specific, their total reported income during periods of intense price competition was from that source.[3]

The practical effect is to permit the independent refinery to initiate pricing practices which can be detrimental to the entire industry. Distribution of cut-rate gasoline to cut-rate dealers can be perpetuated far beyond the productive capacity of the independent refinery in a very competitive market. One should remember that it does not take much to upset any major oil company's refining-marketing balance. In addition, the diversification within the industry is so great that no single firm truly leads in industry pricing; collusion is extremely difficult because of the ever-watchful eye of government antitrust activity, and mistakes in judgment do exist from time to time both in potential demand and optimum refinery size for a short-run situation. All these factors tend to suppress price. Apparently, government economists, well aware of the oligopoly's barriers to competition, have taken a significant step to eliminate some of the barriers within the refining industry. The effect can be observed by examining the average price data during the early 1960's and toward the end of that decade as presented in Table 4.1, page 78.

A study entitled "Oil Supply and Tax Incentives," published by the Brookings Institution, provides additional support for these observations from a different viewpoint.

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[3]More than one direct source. Names withheld by request.

The authors reach the following conclusions about two hypotheses advanced by the Federal Trade Commission:

> Over the period 1951-1972 the real price of gasoline (excluding tax) fell by 25 percent and the ratio of the real price per gallon of gasoline to the real price per barrel of crude oil fell from 9.4 percent to 6.8 percent, a drop of 27.7 percent. ... If the real price of gasoline fell because the majors were aggressively expanding refining capacity and competing for incremental shares of the gasoline market, the cooperative-behavior hypothesis falls. If the majors were cooperatively restraining expansions of refining capacity and the real price of gasoline fell because of expansions of refining capacity by nonmajors, the hypothesis of barriers to entry falls. In our view of the evidence, the real price of gasoline, refinery margins, and long-run profit rates declined both the FTC hypotheses - about barriers to entry and about cooperative behavior - are wide of the mark.[4]

Government activity seems indeed strange when this activity set up in the same mechanism the ability to artificially raise crude-oil price by adhering to domestic supplies of crude and at the same time to lower refined-product price in a rather deliberate attempt to eliminate the price advantages of the oligopoly structure.

RIGID POLICIES

Target fixation is an expression used by United States Air Force personnel to refer to the tendency of some

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[4]Edward W. Erickson, Stephen W. Millsapps, and Robert M. Spann, "Oil Supply and Tax Incentives," ed. Arthur M. Okum and George L. Perry, Brookings Papers on Economic Activities 2 (Washington: The Brookings Institution, 1974). pp. 449-78.

pilots to get so absorbed in the pursuit of their target and so oblivious to their surroundings that they kill themselves and destroy their aircraft just before, during, or just after they attack their target. Success in destroying the target is of questionable value if the concentration required causes one's aircraft to strike the side of a cliff. This phenomenom of target fixation is important to the pilot because of the speeds at which he is moving and the changes in environment that are taking place around him as he pursues his target. Similar things seem to be happening in the business world. Today's business is conducted at a frenzied pace amid rapidly changing circumstances and environment. Are those charged with the responsibility for the determination and maintenance of policy equipped with enough peripheral vision to avoid becoming locked in on a target to the exclusion of rather obvious danger signals? A look at some persisting policies should shed further light on the problem.

Each policy presented is included in quotation marks since it has been paraphrased by the author.

"Low-cost energy is in the best interest of the United States consuming public." This policy or one similarly worded appears to have long been the guiding force of many government regulatory agencies. At this policy's inception the policy was probably sound, and the public in both the industrial and private sectors greatly benefited from it. There is ample current evidence to indicate that the policy is either in need of a change or requires less rigid interpretation. Perhaps the policy should read "relatively low-cost energy is in the best interest of the United States public."

"Big business is inherently evil, and must be continuously and carefully watched to prevent growth, excessive profits, and collusion." There are existing antitrust laws to enforce a portion of this policy. Politicians and reporters assume that it is their civic responsibility to watch other areas. The net result has been to successfully retard profit in the very capital-intense petroleum industry. These actions have reduced return on investment to a figure below the national average despite favored tax treatment for the industry. Improved profits are compared to these abnormally low figures and the general cry is raised that additional safeguards are necessary to prevent profiteering.

"The American consumer desires a large luxury automobile and is not really interested in an economy car." Some automobile-industry executives in the United States could not be convinced that they did not have the proper production policy. These executives followed their previously conceived policy concerning the size and the economy desired by the United States motorist until foreign-car manufacturers captured a significant portion of their sales. Even then they turned their attention more to sporty models rather than economy-oriented small cars. The immediate result of this policy fixation was to produce automobiles which consumed large quantities of gasoline. The eventual result was a major shutdown of large automobile plants and their conversion to the manufacture of smaller cars only after better than thirty million automobiles with high fuel consumption were already on the road. This high fuel consumption added significantly to the total energy problem.

"The type of service station which is most desirable is a large multibay full-service station of modern decor." After several years of this type of construction, it was discovered that the overhead costs would not allow competitive pricing when the cut-rate dealers began to construct minimal service and self-service operations.

"Profit may be maximized by producing additional units whenever marginal revenue exceeds marginal cost." This economic truth may prove dangerous if adopted as a policy without a very clear definition of marginal cost. As suggested in Chapter 3 there is the danger of misconception concerning what constitutes marginal cost in any industry where production is discontinuous (economies of scale require a large plant size and additional units can not be processed when capacity is approached without the construction of a very large plant). An attempt to adopt marginal pricing as it is generally understood under these circumstances can cause a real loss in both capital invested and the ability to attract additional capital.

Policies which appear innocent when considered by one company may develop into mutually exclusive policies when the industry is considered as a whole. For example, if a major oil company decides as a policy not to be undersold by more than one cent while discount competitors adopt a policy of always being two cents under the major price, such a mutually exclusive set of policies exists. There will be, then, no end to the price reductions until one of the firms changes its policy.

The problems existing within the industry which have tended to make prices depressive have been those involving a persistent use of obsolete, poorly defined, or mutually exclusive policies. Most of the pressure exerted against price increases by agencies outside the industry have also been generated due to a rigid adherence to potentially or partially antiquated policies.

GOVERNMENT INVOLVEMENT

The government's involvement in the market place is clearly referenced and quite carefully stated in a policy background paper prepared for a Senate committee. Excerpts from that paper are enlightening:

> OPEC'S[*] success in raising landed prices of imports to the U.S. level would mean an end to the 'cheap imported oil' yardstick against which domestic energy prices have been measured, <u>and the government would be deprived of the</u>

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*The Organization of Petroleum Exporting Countries.

> leverage of increased imports that is now used to stabilize the prices of domestic oil and other fuels.[5]

The policy background paper quotes a cabinet task force on oil-import control

> The present system has spawned a host of special arrangements and exceptions for purposes essentially unrelated to the national security ... and had led to undue Government intervention in the market and consequently competitive distortions.[6]

The policy paper further states "The import control program is now principally a price stabilization device and a means of allocating the benefits of import among refiners."[7] This allocation is done in a biased manner as indicated in the policy paper "... the 'sliding scale' favoring small refineries."[8] The sliding scale referred to is presented in Table 4.5, page 103, and the benefit of the import quota is presented in Table 4.4 on page 101.

> The absence of clear legislative authority and guidelines for oil import policy, the general practice of deciding import matters on an ad hoc basis, and the drift in administration of the existing program, constitute uncertainties that deter investment in several sectors of the energy economy. Among these sectors are ... refinery location and construction.[9]

Many of the areas of government involvement have

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[5]U.S., Congress, Senate, Committee on Insular Affairs, Toward a Rational Policy for Oil and Gas Import - A Policy background paper, 1973 (Washington: Government Printing Office), pp. 9-10.

[6]Ibid., p. 14. [7]Ibid., p. 15. [8]Ibid.

[9]Ibid., p. 16.

been mentioned in previous sections of this chapter. In addition to those mentioned, President Truman requested and received from the industry cooperation toward a million-barrel reserve capacity which suppressed prices in the early fifties (prior to the adoption of the oil-import program).

PROBLEMS WITHIN THE INDUSTRY

The balance between refining and marketing for major oil companies is a precarious one with extremely unstable characteristics. This lack of stability is caused by the application of marginal pricing in a questionable manner.

Thorstein Veblen has a rather clear exposition of the price system in a free-market economy in his book, The Engineers and the Price System.[10] He illustrates the effect of overproduction on prices by referring to the capacity of the United States during times of war to mobilize production facilities and turn out tremendous volumes of any selected product (tanks, trucks, aircraft and the like). He suggests that this extensive production volume could also be accomplished during times of peace; however, it would suppress prices by creating hugh surpluses of any given product. These lower prices would be self-defeating from a profit oriented viewpoint. Veblen therefore concludes that it is essential under our economy to control production.

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[10]Thorstein Veblen, The Engineers and the Price System (New York: Viking Press, 1954).

This premise is accepted in almost every major manufacturing area. Business personnel produce and utilize carefully calculated inventory control programs. A manager in today's business world would be remiss and subject to open criticism if he allowed inventories to run rampant, to absorb excessive quantities of working capital, and eventually to become obsolete. Despite this fact there is general presumption that any attempt to control production in the refining industry has to be blatant conspiracy.

There were several causes for the lack of stability within the industry. The government's intervention in the market place was of major importance since this external disruption of the market economy appeared to be an internal disruption of the market economy. The independent refiner, given a protective blanket under the import program, had on occasion used that protection to engage in practices he would have hesitated to attempt if such windfall profits were not rather uniquely available. Despite the fact that there was encouragement, the extent of price competition in the industry appears excessive. Outside influences, although responsible for the initial thrust, were not fully responsible for the magnitude of price-suppressive activity.

A combination of misapplied marginal cost principles and self-serving purchase timing has greatly amplified the problem. To illustrate the effect of the combination of these two forces, consider a situation in which a major oil company has carefully calculated its total requirement for heating fuels for the winter season. Although there is considerable manufacturing flexibility within the refinery, a hypothetical company has concluded that it cannot produce all the requirements during the peak season without getting an early start. The company commences the production of normal requirements considerably ahead of the season and stores the output pending sale to independent jobbers. The jobbers, well aware of the total storage capacity at a given refinery location, purposefully delay the acquisition of heating fuel. During this interim period they almost totally deplete their inventory of product. At the point where the major refinery has exhausted its storage capacity and is considering negotiations for extensive transportation costs, not normally incurred, the jobber begins to bargain with the major refinery. Due to the pressures of sheer volume and absence of storage capacity, the major refiner is caught in a weak bargaining position and sells at low prices. One available recourse which would avoid such disastrous results, when the bargaining position of the independent is strong, is to purposefully delay the changing of the product mix so as to produce less than the anticipated demand for the product and to thus avoid exhausting storage capacity. The major companies have repeatedly been unwilling to do this.

Another alternative which could be effectively used to avoid depressed prices would be to purposefully curtail production volume whenever a significant segment of the product mix is in oversupply. In this area the lack of acceptance of marginal cost in its application to the unique aspects of the refinery industry has caused the major oil companies to adopt policies promoting heavy utilization of plant capacity at the expense of price. Independent marketers of gasoline, well aware of the policies adopted by the major oil companies, utilize products obtained from independent refiners to gain a foothold in the market place. Drastic discounting policies are adopted and can be maintained because the independent refiner's price is below the major's price. In addition, the marketing costs of these service stations which provide almost no service other than the delivery of gasoline are considerably below the costs involved in a full-service station because of the great difference in fixed costs. After obtaining a small foothold the marketing policies of the independent attract a portion of the major refiner's sales. This sales-volume loss creates a chain reaction since a loss of sales volume places the major refiner in an excess-capacity situation. This temporary oversupply of product has been "created" by brand name and does not exist when total supply and demand are considered. The policy to maintain production volume causes the major refiner to sell his excess product at attractive rates to the independent marketer. An attractive rate is one which is lower than the rate supplied by the independent refiner. This low rate enables the independent marketer to again reduce his price and the cycle repeats itself.

In addition to the reasons previously mentioned, there have also been some instances where poorly worded contracts have created a price-suppressing effect. These contracts take the form of a guaranteed profit margin or express the price in relative rather than absolute terms, such as some relative price below the normal tank-wagon price. In these instances there is no sharing of responsibility in the pricing scheme. Regardless of how low the price goes, one party to the contract is still assured his normal markup. On occasion one party to such a contract has been known to initiate the price-suppressive activity thereby automatically lowering his cost and attempting to stockpile product at a low cost. Inequities of this sort are usually of short duration because the injured party is not again interested in entering into such an arrangement.

ECOLOGICAL CONSIDERATIONS

Any attempt to segment the various facets of the problem associated with refining is subject to criticism. Most of the effects of any one portion of the industry are interwoven with the circumstances in other segments. This interlocking relationship is especially true of the effect of concern for the environment upon the industry.

There can be little dispute with the fact that environmental concerns are a real and timely problem and that the refining industry should make reasonable efforts to minimize atmospheric pollutants. The primary problem in the interaction of ecological and refining needs has been one of timing. Environmentalists were interested in halting known pollutants and preventing further abuses to the environment. Strength for the cause was received from the Environmental Protection Agency. Although it is reasonable to assume that individuals would react emotionally to challenges to the environment, it seems also reasonable to assume that the Environmental Protection Agency should react more calmly and on known facts rather than emotions. In some instances this does not appear to have been the case. There are three major areas where environmental concerns have seriously affected the normal operation of petroleum refining, and a fourth area which has resulted in tremendously increased demand for petroleum products.

Removal of Lead

The first area of concern was caused by the legislation requiring elimination of certain emissions from car exhaust. Because of the approach that the United States automotive industry followed to meet its emission requirements (namely, the use of catalysts), the refining industry was forced to prepare for low-lead and eventually no-lead gasoline. This preparation was essential to prevent a fouling of the catalyst by the lead which would render the catalyst useless. In addition to the no-lead requirement, United States auto makers had to severely reduce the performance of their engines by reducing compression ratios.

These lower compression ratios increased the demand for low-octane gasoline rather than premium gasolines. At the same time the technology associated with producing reasonably high-octane gasoline containing no lead required additional processing using equipment whose function was to increase the octane. Refiners thus had the capability of delivering a leaded gasoline with high octane ratings when the short short-run demand was for gasoline with relatively low octane. In this instance, the political body which established the mandatory policy provided lead time. However, in view of the technical requirements, the lead time was quite short. Following their usual policy, the government regulations provided favored treatment to small refiners. The major refiners have only until 1975 to accomplish the conversion; however, the small refiners have until 1977. The short time period for the implementation of the emissions standards, which was cut even shorter by some of the states, has created a doubt in the minds of some industry leaders as to the need for the strict measures required. There is some evidence to support the claim that eliminating the lead was an unnecessary requirement. Given the same crude stocks, refineries will be unable to produce the same volume of gasolines containing no lead that was previously produced utilizing the lead. The automobiles will of course consume more product since the compression ratios have been reduced.

Refinery Emissions

A second impact of environmental concerns on the refining industry was the requirement that the refinery clean up their own emissions. Substantial earnings of the companies have been diverted from other sound investment proposals to accomplish this objective. Despite these efforts and disregarding the fact that entirely new refinery facilities were being constructed to meet emission standards, politicians on the eastern seaboard (primarily in the Northeastern United States) were successful in defeating proposed refinery construction sites in that sector. They have also vigorously and successfully opposed the construction of superports to handle large tankers transporting foreign crudes. One result of this action (which created large deficits in refinery capacity for the PAD[11] district) has been a hostile attitude on the part of some state and local officials toward the exportation from their producing areas of refined products to areas that had deliberately blocked refinery expansion.

Alaskan Crude

The third impact of major significance directed against the petroleum industry by environmentalists was the blocking of the efforts to construct the Alaskan pipeline which would transport Alaskan crude from the North Slope to

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[11]Petroleum Administration for Defense.

an open seaport. The ability to transport this volume of crude does not begin to reach the magnitude of the current domestic crude deficit, although Alaskan crude provides a potential for a significant temporary relief from extreme hardship when transportation problems are solved.

Generation of Electricity

A less-direct area of ecological impact which must be considered is the environmentalist's successful attempts to halt construction of new facilities for hydroelectric and atomic generation of electricity. This deferred construction has a significant bearing on the petroleum industry. The sulfur emissions requirements outlawed the use of most coal as a power source causing the producers of electrical energy to convert from coal to residual fuel oil or gas which drastically increased demand for both refined products and natural gas. The timing of these problems was critical because it introduced uncertainty into the decision model at a time when return on investment was low, as noted in the following section.

EFFECT ON FINANCIAL INVESTMENT

Refinery capacity in the United States has grown from 9,916,165 barrels per calendar day in 1963 to 13,382,955 barrels per calendar day in 1973 (see Appendix A beginning on page 161). During this same period of time the Oil and Gas Journal forecast demand for domestic consumption and exports increased from 10,656,000 barrels per day in 1963 to 17,460,000 barrels per day in 1973 (see Table 4.6). Forecast demand exceeded refinery capacity in 1963 by approximately 740,000 barrels. However in 1973, forecast demand exceeded capacity by more than 4,000,000 barrels. What produced the tremendous lag in refinery investment?

Governmental policy decisions are apparently responsible for most of this difference. In 1963 the forecast of United States import of refined products and unfinished feed stock totaled 940,000 barrels per day. By 1973 the forecast indicated 2,901,000 barrels per day of finished-product imports (see Table 4.7 on page 123). What appears then to be a constantly increasing gap between forecast demand and domestic capacity is in reality a planned difference -- planned by persons in United States Government agencies. To appreciate the real situation facing refiners, it is necessary to remove the forecast imports from total forecast demand to obtain the "real demand" envisioned by the industry. Figure 4.5 and Table 4.8 both depict this comparison of refinery capacity to the more realistic forecast of domestic production requirements.

There was a slight excess of capacity in 1963 and 1964 which apparently caused refiners to stabilize investment from 1964 to 1967 as there are only very slight increases during that time. Except for 1967 and 1968, the sizable increases in demand beginning in 1965 and continuing in 1973 prompted refiners to commence

Table 4.6

Forecast of Demand for Domestic Consumption of Refined Products and Exports with a Constant One Year Lead Time (Thousands of Barrels Daily)

Year	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Domestic Demand											
Gasoline	4,476	4,588	4,827	4,847	5,074	5,140	5,445	5,740	6,074	6,247	6,682
Naphtha	...	...	...	89	86	...	...	...	...	...	...
Kerosine	261	254	254	267	269	260	278	280	255	252	231
Distillate	2,024	2,061	2,107	2,159	2,233	2,330	2,355	2,560	2,677	2,822	3,051
Residual	1,485	1,514	1,526	1,633	1,754	1,800	1,878	2,050	2,447	2.360	2,781
Jet Fuel - Military	323	330	339	376	453	580	677	790	784	801	849
Jet Fuel - Commercial	201	233	253	284	283	315	371	300	209	236	247
Lubricants and Naphtha	121	121	127	...	140	...	...	...	...	...	...
L P Gas	747	684	718	762	933	1,015	1,115	1,280	1,334	1,329	1,446
Asphalt and Road Oil	347	355	362	374	399	...	...	...	...	...	...
Other	690	618	632	1,076	656	1,615	1,659	1,775	1,762	1,802	1,947
Refinery Loss	-178	-208	...	...	...	-315	-314	-325	-387	...	...
Chem. Feedstock	...	259	303	...	223	...	...	...	...	...	...
Total Domestic	10,497	10,809	11,448	11,867	12,503	12,740	13,464	14,450	15,161	15,849	17,234
Exports	159	179	189	189	196	225	244	230	245	241	226
Total Demand	10,656	10,982	11,637	12,054	12,699	12,965	13,708	14,680	15,406	16,090	17,460

Source:

Oil and Gas Journal Annual Forecast Numbers from 1963 to 1973.

Table 4.7

Forecast of Finished Product
Imports 1963 - 1973

(Thousands of barrels daily)

Year	Imports
1963	940
1964	1,020
1965	1,123
1966	1,274
1967	1,394
1968	1,520
1969	1,602
1970	1,830
1971	2,304
1972	2,362
1973	2,901

Source: Oil & Gas Journal, Annual forecast numbers 1963-1973.

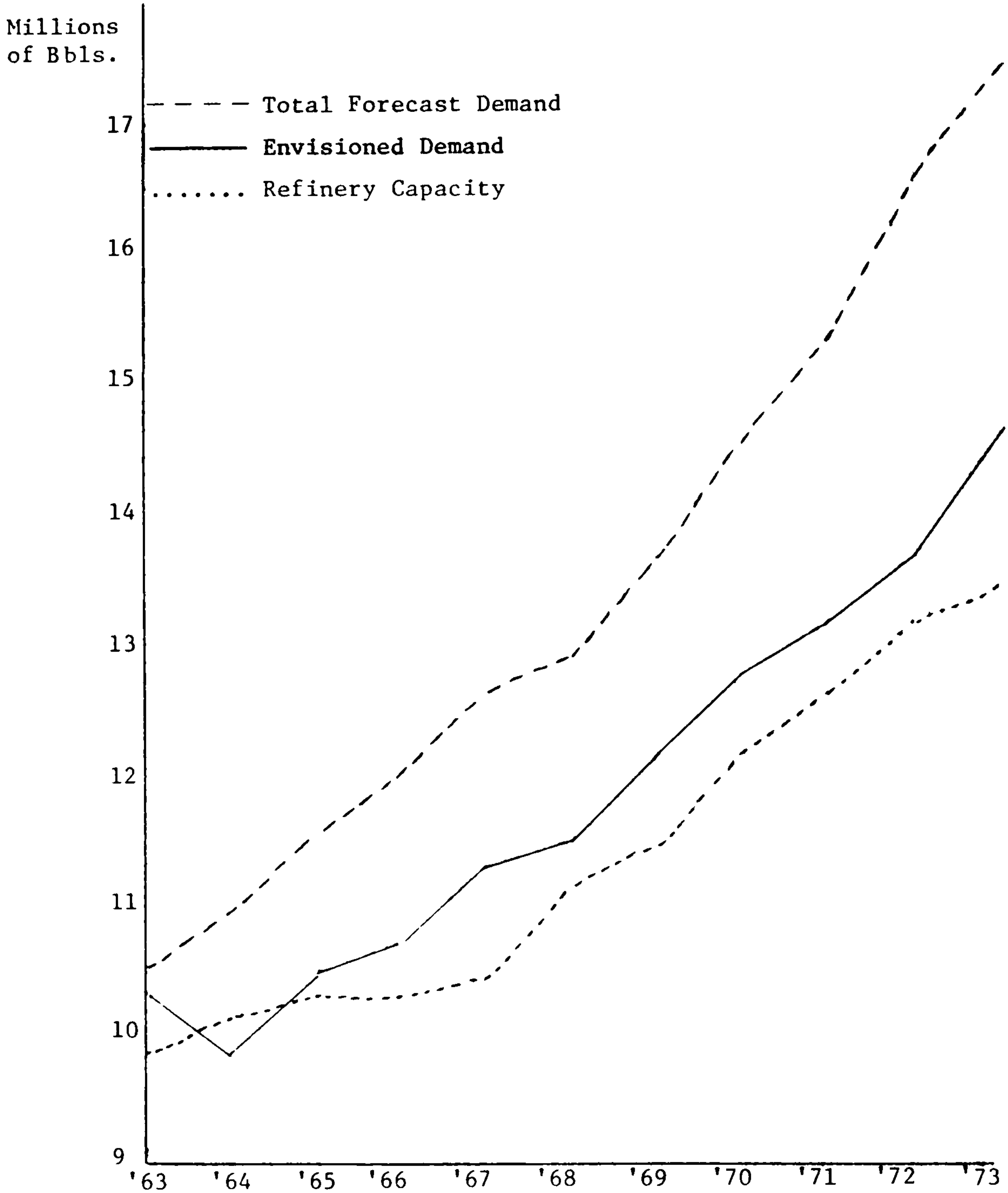

Figure 4.5

Comparison of Forecast Demand Net of Refined Imports with Refinery Capacity

Source:

Table 4.6
Table 4.8
Appendix A

Table 4.8

Envisioned Demand - Forecast Demand
Less Forecast Finished
Products Imports

Year	Net Demand
1963	10,310
1964	9,968
1965	10,514
1966	10,780
1967	11.305
1968	11,445
1969	12,106
1970	12,850
1971	13,102
1972	13,728
1973	14,559

Source:

Oil and Gas Journal.

Tables 4.6, 4.7.

construction activities on an intensive basis during 1967, but the increases for subsequent years appear to be at a declining rate. The three to four-year time lag (1964-1967) between the demand increase and the construction increases is indicative of the lead time necessary to construct refineries.

If normal market forces had been at work, prices should have increased in 1965, 1966, and 1967. They should have fallen off slightly in 1968 and then moved upward at a slower pace. A reference to Figure 4.1 (price chart), page 79, will reveal that although prices were declining on a seasonal basis in 1963 and 1964 (the result of the temporary oversupply), they never regained their former status; rather, they were suppressed by the market-controlling influence of the import program from the end of 1964 until the early 1970's. There is therefore a lag of five years following the rapid demand increase which started in 1965.

This time lag was created because officials in the refinery industry were optimistic. During periods of depressed prices of the mid-1960's the prevailing attitude was "the price will get well," and, because of the lead time required for refinery construction, this attitude sustained refinery expansion through a prolonged period of depressed prices. By 1969 and 1970, the industry had received the message concerning prices and realistically viewed price expectations to be low. At the same time, forces behind the ecology movement had gained strength and were presenting the industry with uncertainties. If return on investment had been greater the industry may have proceeded with expansion despite the uncertainty. However, with return on refinery investment, particularly for a totally new refinery, at a sustained low level, the risk of uncertainty became the probability of loss because there was little margin for error.

Responsible corporate officials who were interviewed and questioned regarding investment decisions all indicated that the return on investment for totally new facilities was indeed marginal and those firms that proceeded to invest did so for other compelling reasons, not because the investment proposal sold itself on a financial return basis.[12] The situation was so obvious to an astute observer of the industry that one informed writer stated, "Despite positive demand, there is indecision in the HPI[*] today. Decisions are being delayed because of many uncertainties, particularly pollution control."[13] Fisher and Phipps in a subsequent article in the same series added,

> The consequences of misjudgment are today being amplified by: (a) a loss of flexibility in fuels refining as lead restrictions are imposed, (b) the outside influences on raw materials cost, and (c) the assumption of control by legislative and regulative bodies. The chances that overbuilding

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*Hydrocarbon Processing Industry.

[12]Names withheld by request.

[13]James N. Fisher, Jr., "Analyzing HPI Intermediates," Hydrocarbon Processing, L (February, 1971), 95.

capacity will result in severe profit losses, for example, are far higher today than in the past. Losses in potential profit from underbuilding of capacity are also higher today than in the past.[14]

SUMMARY

The normal domestic competitive forces in the petroleum refining industry were not allowed to work alone. The dual pricing structure introduced in 1959 which purported to uphold a higher domestic price for crude oil set in motion numerous activities which ultimately suppressed product prices. Returns from the production of crude oil thus appeared more attractive than the book losses which frequently surfaced in the refining and marketing sectors. Management eventually, after prolonged depressed prices, shifted substantial investment to the production phase when additional uncertainties caused by ecological considerations indicated a high risk of loss on proposed refinery investment. If the return had been greater, refineries could have been built and modified to meet changing environmental restrictions.

During this same period government policy pertaining to the importation and pricing of residual fuel oil caused a great difference between actual demand and envisioned demand. Actual demand reflected total potential

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[14]James N. Fisher, Jr. and A. J. Phipps, "Quantifying HPI Uncertainties," Hydrocarbon Processing, L (March, 1971), 70.

consumption in the United States, and envisioned demand represented this total, less envisioned imports, under existing government policy. After foreign powers were allowed to indirectly control substantial quantities of domestic heating and power-generating fuel supplies, the policies adopted by the Organization of Petroleum Exporting Countries disrupted operational levels worldwide. The foreign countries supplying the United States with residual fuel oil judiciously met their own needs first. Government policy thus created a significant portion of our "energy crisis" in an attempt to prolong extreme "low-cost energy." Numerous other regulatory policies, as well as a misapplication of marginal costing principles by the industry, contributed to suppressed product prices either by a reduction of cost to selected refiners or by discriminatory, artificially low competitive price both outside and within the refining industry.

The rigidity with which policies were followed, despite changing circumstances, contributed significantly to the inflexibility of price. These rigid policies were especially significant when applied by government regulatory agencies, but were also noted within the industry. Careful examination of the empirical data presented in this chapter strongly supports the hypothesis that prices have been semirigid and that forces outside the petroleum industry have played a significant role in producing this upward rigidity. A partial result of the rigidity, although not the main thrust of this study, was the recent crisis within the industry. Empirical data indicated the presence of price-suppressive artificial activity in the price structure of the petroleum-refining industry. The effect of this price-suppressive activity on investment decisions is examined in Chapter 5.

Chapter 5

DECISION PROCESSES EXAMINED

Identification of causes of semirigid prices was not too difficult when the actions of various interest groups were overt and publicly defended. The more subtle causes were harder to detect and disclose. The effects of price rigidity on the refining industry were even more difficult to measure. Empirical data obtained during unstructured interviews with key industry personnel assisted greatly in obtaining the viewpoints of executives in the planning areas of the petroleum-refining industry. Some of the questions considered while gathering and analyzing this empirical data follow:

1. Which companies should be contacted?
2. How could a cross-section of the industry be obtained?
3. What were the impacts of price rigidities on financial planning?
4. What light would a postcompletion evaluation shed on investment decisions made during the time period under study?
5. To what extent is traditional joint-cost-accounting allocation used in the investment model?

A review of the methodology used in this study will assist in the readers evaluation of the empirical data.

The summarized results of each individual interview have been presented in Appendix E, beginning on page 216. As promised during the interviews no disclosure was made of either the names of the firms or the names of individuals representing the firms being interviewed. Without this guarantee much of the detailed information discussed during the interview would probably have been unavailable. Post-completion audit evaluations, made available on a voluntary basis by several of the companies interviewed, were reviewed. Once again sources were not disclosed.

METHODOLOGY

A detailed list of total refinery capacity by company for the last decade is presented in Appendix A, beginning on page 161. Since investment in new refinery construction is of primary concern, the figures reflect refinery capacity as controlled by the companies in 1973. The figures, therefore, include additions to capacity as though these additions were owned by the acquiring company even prior to their acquisition. This approach allows the reader to determine growth by construction directly from the tables in Appendix A. The companies were ranked by size in order of descending capacity. The growth (by new construction) in refining capacity of the fifteen largest companies for the last eleven years (1962 through 1973), is presented in Figure 5.1. Every company in the industry was

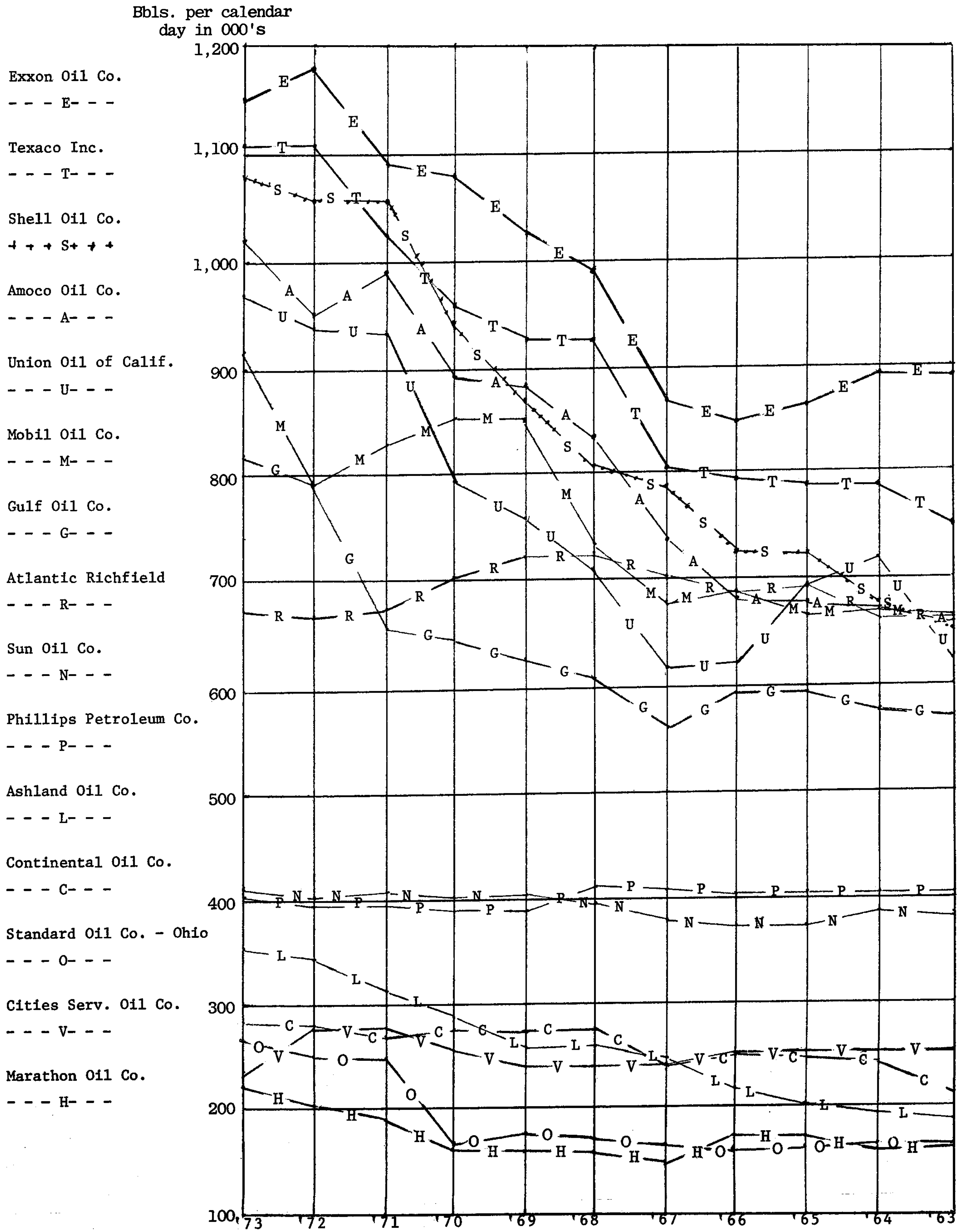

Figure 5.1

1973 Refinery Capacity Controlled by the Fifteen Largest Domestic Refiners in Descending Order

Source: Table A.1.

graphed during preliminary investigation to determine each firm's relative growth pattern.

Preliminary investigation revealed the strong probability of both a difference in management attitude and a difference in return-on-investment for firms of different size. A random sample was rejected in favor of a judgment sample to ensure that firms representing each different stratum would be selected. A stratified random sample was also considered impractical because the confidential nature of the interview might preclude cooperation by randomly selected participants, thus defeating the random selection. The companies contacted were specifically chosen as representative of particular growth patterns or to represent a particular size firm or both.

Originally, twenty-four firms were contacted and together they represented over 5,000,000 barrels per day of refinery capacity. The firms ranged in size from those in excess of 1,000,000 barrels per day to those with less than 3,000 barrels per day. One very large firm and one small firm refused to cooperate in the project. Another small firm also declined but in revealing the reasons answered in detail a portion of the information sought. Another firm's president was cooperative but his firm had acquired refining capacity so recently as to negate the value of responses in an interview. One firm which could not be contacted in follow-up action was in the process of being acquired by another firm that had already cooperated. Four other firms originally contacted to ensure an alternative if some did not cooperate were of such similar size and operating characteristics to those contacted that no follow-up was initiated when no replies to the initial inquiries were received. All the remaining companies allowed an interview. The degree of cooperation was left entirely to the discretion of the firm's representative and ranged from cordial and open responses (which sometimes included actual formal postaudit evaluation reviews) to guarded, nonrevealing interviews. Even in the latter instances, however, specific answers were obtained to carefully worded requests which revealed the trend or management intention of those firms.

Initial contact with each firm was made by letter, and thirty to sixty days later, follow-up was made by a telephone call to the presidents of those firms not responding. There were no rejections or lack of cooperation once personal voice contact was made with a responsible official.

The large firm that refused to cooperate was the first one of that size contacted. Although there were indications that the rejection was a standard policy, subsequent contacts with other firms suggested that approaching the firm on too low a management level was a poor policy. The preferred approach proved to be a written communication directed to the chief executive officer of the firm.

COST ALLOCATION METHODS IN USE

No uniform method for allocating costs among the existing product mix was observed in the firms contacted. Some firms strongly favored a volume-based allocation. Others preferred a price-relative allocation for limited purposes (inventories) but not for managerial product mix decisions. One firm was using a cost differential which was essentially the cost of upgrading the last unit which had been changed to a lighter fraction by the latest techniques available. This method ignores the "natural" yield of high-revenue products when allocating a barrel of oil and would substitute as a premium on the cost of gasoline the differential involved in upgrading the last unit of the distillates changed to gasoline. This differential was then applied to all the barrels of gasoline produced even though no such costs were incurred in their production. By the same token no premium was associated with the gasoline component of the crude-oil barrel other than this latest differential.

Representatives of each firm contacted were asked to identify the allocation method used for managerial decisions involving product mix. Without exception each individual responded quickly that no profit could be determined by product lines. Those firms with computer capacity suggested a total cost - total revenue approach to the problem. This method utilized computer models of the specific refinery to determine the impact of altering the product mix within the limits of refinery configuration. The pilot firm (see Company M in Appendix E, page 236) determined that costs of three different products were identical throughout the refinery's normal operating range using this method. Closer inspection disclosed a very heavy bias in the computer model favoring a volume allocation of the input crude-oil barrel. This bias existed in all but one of the intermediate and large-size firms contacted. The smaller firms' managers indicated the same bias; however, without computer models the bias was not defended by them as strongly as by representatives of the larger firms.

Under Phase IV Price Controls refiners were required to identify profit by product lines. Despite strong protest that complying with this request was impossible, the firms had to respond. The technique which evolved reflected the bias in favor of volume, and this method was later required. Several small refiners seemed to find the government reporting requirements and the controls on various products such a problem that they sold out to intermediate-size companies to avoid the headaches. The firms that were acquiring did so to reduce some of the product-mix balance problems that government regulations had imposed on them.

Numerous additional items of individual interest are located in the interview results reported in Appendix E on page 216. However, one of the specific reasons the firms were contacted was to conduct or examine the results of postcompletion audits.

POSTAUDIT EVALUATIONS

The following analyses have been made by reviewing postaudit evaluations or implemented proposals. To ensure the anonymity of the companies involved, the postaudit evaluations will be referred to by omitting any identifying characteristics of either the company or the facilities unless those facilities are in common use in the industry and would not identify the firm.

Case I - A Totally New Petrochemical Plant

The first case is a decision to construct a new facility in an attempt to retain a declining relative market share. The initial proposal indicated the competitor's advantages to be:

1. market-oriented plant location.
2. more intense sales and service activity.
3. greater research and development efforts.
4. wider range of products.

This initial study indicated an average annual rate of return on investment of 18.46 percent with payout to occur in 4.8 years. The personnel presenting the proposal suggested that improved performance from existing locations would result from construction of the new plant. These improvements were included in the projected return. The postaudit evaluation by company personnel cut right to the heart of the problem. The new plant did not live up to expectations in sales, and incurred greater expenses than planned, causing the audit personnel to observe:

> The premises that a plant in ... would enhance market prices and volume in other areas (or that unfavorable consequences would result without such a plant) is, in our opinion, debatable and highly speculative for use in project justification.[*]

In the original proposal this speculative improvement amounted to 33 percent of the project income. The postaudit evaluation explained all significant deviations from projected performance and revealed a reduction in the average annual rate of return of 9.5 percent (more than half) and an increase in the years to pay out from 4.81 to 8.5. This was an expensive lesson in totally new petrochemical-plant construction.

Case II - Refinery Modernization and Expansion

A dual proposal was made to upgrade the "bottom of the barrel" (see Figure 2.1 on page 36) and to expand total processing capabilities for an existing refinery. Anticipated new specifications for asphalt were expected to be more restrictive. Existing refinery configurations would not permit production of the new asphalt and would require the residual to be sold as fuel oil. A modernization of plant would prevent a loss of revenue. In addition, a planned 2,500-barrel-per-day increase in capacity (as first considered) coupled with the revenue from asphalt retention,

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*Audit group identity withheld by request.

produced an average annual rate of return on investment in the initial study of 17 percent with payout to occur in 5.2 years. In the first six years differences in product prices and increases in crude-oil prices and manufacturing expenses reduced the average annual rate of return to 7.7 percent and lengthened the payout period to 9.4 years.

Case III - Expansion To Meet Emission Requirements

An investment proposal was examined which was used to implement an upgrading and expansion of refinery plant to meet the new 1975 Federal emissions standards. Built into the calculations were figures reflecting opportunity costs of not having product available for sale. In addition, it was assumed that no-lead gasoline would command a premium price. There was also an assumption that number six fuel oil would have a sustained high price. With these assumptions, the project showed a return on investment in excess of 25 percent and represented a proposal that would carry its own weight on a financial-return basis.

The premium price on no-lead gasoline did not materialize and return on investment dropped appreciably. This expansion was recent and improvements in the number six fuel-oil price coupled with general increases in other product prices salvaged the investment. The new equipment added catalytic cracking and Platforming capabilities which provided an enviable flexibility and increased the company's overall capacity.

Case IV - Major Expansion

The results of an expansion decision and a review of the postcompletion effectiveness of that expansion were discussed with the person responsible for the planning and postaudit of the expansion. The data given are considered valid, but no written evidence was observed. As a consequence the results were reported in Appendix E under Company R (beginning on page 229).

Case V - Construction of a Totally New Refinery

The review of a totally new refinery-construction decision was made during an interview with the official responsible for planning and monitoring the expansion. The specific facility was identified and some confidential information pertaining to its unique features was presented. The firm's representative was open and candid, had extensive knowledge of the entire operation, and spoke rather freely. He understood that the confidential portion of the material would not be published nor the firm identified. Since no written matterial was examined, the results of this interview were presented in Appendix E under company T (beginning on page 224).

Case VI - Small Upgrading of Facilities

The results of a brief verbal exploration of a post-completion evaluation is presented under Company H in Appendix E (beginning on page 239).

SUMMARY

The results of contacts with the firms in the petroleum industry proved to be invaluable to the author. In addition to a good response (sixteen out of nineteen companies on which follow-up was initiated) the firms contacted were for the most part very cooperative.

None of the firms could refute the logic of government involvement and effective price ceilings for the latter part of the decade 1962 through 1972 (the basic content of Chapter 4). Neither did they take issue with the logic presented in Chapters 2 and 3. The development of the economic thrust of Chapter 3 was discussed with the members of the economics departments of several large firms and with the chief executive officers or planning officer of some small and intermediate firms.

Seven actual investment cases were discussed or studied. Six of the seven cases were presented. The seventh case was a detailed written proposal which had not been implemented. This case was received as the result of a direct request for a negative decision on an investment proposal. Together the proposals reviewed represent a fair cross section of industry activity ranging from the construction of a large, totally new refinery through major refinery modification, and included small additions and technological upgrading to meet emissions requirements. A facility other than a refinery was included to indicate the coverage of very limited petrochemical analysis (limited to a postaudit evaluation). Of the firms contacted, those which responded represent approximately 30 percent of the total refinery capacity in the United States at the beginning of 1973.

The interviews disclosed a basic trend. Return on investment for totally new refineries was so poor during the latter portion of the decade (1967 through 1972) that the few facilities actually built were constructed primarily because they could not be avoided or because the construction meshed with other critical decisions, and not because projections indicated a favorable return on investment. Expansion in the intermediate-size firms was more inclined to take the form of expanding sophisticated equipment and balancing existing facilities to take advantage of previously overdeveloped components. This attitude also spilled over into the large refineries when expansion studies indicated that the return on totally new refineries was inadequate. The intermediate companies had primarily adopted these policies because of capital limitations.

Smaller companies continued the established trend of making small improvements from time to time with heavy utilization of used equipment obtained from larger firms' discarded facilities. A few small firms were planning for eventual upgrading to no-lead gasoline which involves heavy capital expenditures for new equipment. This upgrading of facilities is not mandatory for smaller firms until 1977. There was, therefore, no general rush to costly upgrading and the return on investment indicated by the small firms was quite high.

No use was made in the investment model of traditional joint cost-accounting allocation. Instead, there is a creeping movement toward a volume-oriented cost allocator. This attitude was most vocally represented by the large firms with extensive computer models, but was prevalent throughout the industry without regard to refinery size. Government regulation required the use of a volume-based cost allocator under Phase IV price controls. Accounting systems have been modified extensively to meet that requirement. The academic world had little if any knowledge of this forced change and less opportunity for input into the transition to an allocation system based on volume.

Chapter 6

SUMMARY AND CONCLUSIONS

Petroleum refining has changed steadily since about 1906 from a processing to a manufacturing activity. Among other gradual changes, capital requirements for expansion have increased dramatically as the optimum size of the refinery has become larger. The pace of the general business environment has also increased markedly. Government involvement in areas affecting the petroleum-refining industry has become more and more pronounced.

EFFECTS OF POLICIES

A combination of forces produced a period of semi-rigid prices in the industry. An unyielding adherence to policies when subtle changes in the business environment produced a need for policy modification or abandonment appears to be a primary cause of price rigidities.

Government Policy

Government officials vigorously pursued a low-cost-energy policy which had a threefold effect. First, the price of natural gas was held extremely low by a regulatory agency (the Federal Power Commission). The commission was not negligent in its duties nor did it intend to create a crisis. The problem in retrospect seems to be in part one of accounting.[1] With whatever justification, the price of natural gas was held artificially low. This produced additional demand for the product both from areas previously serviced by gas and also from electric-power-generating facilities previously fueled by some ecologically restricted source. With no incentive for capital expansion to meet the huge demands now being placed on the resource, the natural gas industry simply could not keep pace.

The second phase of rigidity in governmental policy administration occurred in fuel-oil handling. Residual fuel oil was cleaned up through technology to meet the standards imposed by the Environmental Protection Agency. Consequently, there was an increased demand for this fuel to substitute for the less-expensive gas since the gas was available in short supply. Shortages were felt due to this

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[1]The price of natural gas could be held low and justified only by a rigid insistence on review of past cost (the extremely low costs associated with the discovery of yesterday's natural gas). The theoretical reasons for historic costs versus replacement costs have been discussed by many persons with impressive credentials. However, the depreciable assets normally discussed during these theoretical inquiries have risen only modestly when compared to the tremendous increases involved in drilling in today's deep-pool, high-cost drilling ventures.

expanded use as much as three or four years ago and newspaper headlines proclaimed a shortage of fuel oil. These headlines caught the writer's attention and motivated this study.

Careful inquiry revealed no absolute shortage of residual fuel oil at that time but rather a shortage at the existing price. The price of heavier residual fuel oil has been so low that most major refineries have processed the residual into asphalt or coke. Relatively cheap foreign crude combined with lower foreign labor costs induced the construction of refineries outside the United States as the primary source of supply for United States residual-fuel-oil requirements. Government forces went to work when the shortage was publicized. Following rather rigid adherence to their previous policies in an attempt to keep the price low, import restrictions were reduced and eventually removed. This action allowed foreign sources to meet domestic requirements in an ever-increasing pattern. Total petroleum consumption was skyrocketing but the form of the demand was in a relatively unprofitable product as far as the existing policies of United States refineries were concerned. The policy of protective governmental agencies would not allow the product to become more profitable.

The third major effect of rigid administrative policy assumed a more subtle form. At its inception the oil-import program was intended to "protect" the industry from a glut of foreign crude oil readily available at a low cost.

This action seemed to be a major reversal of policy in that low costs were being pursued in other areas. The primary intent appeared to be the preservation of employment in the United States petroleum industry. Government, however, is large and the low-cost-energy pursuit continued.

No sooner had the import program become mandatory than the program itself began to be used to suppress the price of refined products, particularly gasoline, which had no natural competitive substitute. At the same time crude-oil prices were held high, the price at the pump was being attacked from two sources. Marginal producers were armed with a relatively low-cost product due to a reduced cost of crude under discriminatory import quotas. Smaller refineries were allowed a greater percentage of import quota compared to their total refinery capacity than were larger refineries. There is evidence that some marginal refineries were acquired from major oil companies and the resultant improvement in import allowables in effect provided an inexpensive acquisition. The resultant savings reduced the investment cost in these discounted, used facilities even further and shortened payout. This action allowed a low-cost gasoline to meet the low return on investment requirements. Government policy which was designed to keep the marginal producer competitive also presented problems with respect to new construction.

The extreme discontinuities being required in totally new refinery construction created, for any single firm, a problem in locating sufficient demand to satisfy the output requirements of the large refineries. Historically, the gradual replacement of older facilities produced some of that demand. Since the older marginal facilities were being operated with a subsidy, the investment decision on the larger new facilities became even more risky than they had previously been. Thus the indirect effect produced by the government through the marginal refiner has all the outward characteristics of natural competition from smaller (purportedly less-efficient) operations.

The direct effect was even more devastating. The price of gasoline was driven down by complex combinations of government policy interacting with a marginal-cost pricing scheme which produced an unstable price-depressing effect in the industry. Once prices were depressed sufficiently, the direct action of governmental low-cost energy policy went into effect. The government applied direct pressure on the industry and on any natural leader of the oligopoly market by threatening to roll back the price of crude oil through complete removal of the import controls. This action would have produced the flood of inexpensive foreign oil that the import controls were originally installed to safeguard against. This direct external pressure forced several industry leaders to roll back announced price increases during a period when cost to the industry (in all phases of operation) were rising in keeping with the overall price level. In the author's opinion, it appeared almost as if petroleum products and other energy sources were singled out as exceptions to the inflationary spiral of this time period, primarily because of the low-cost energy policy.

Other Policy Problems

In addition to the major effects of government policy, a relatively minor but still significant effect was felt in the competitive pressures brought by the electric utilities against home furnace fuel through artificially low, discriminatory, "off season" pricing schemes which were coupled with total-electric advertising. The net effect of this combination was to perpetuate justification for artificially low heating rates. The resultant increases in the use of electric heating placed even further demands on the petroleum industry, but shifted the demand from the distillate range which was produced domestically, to the residual range which was imported.

The United States Government was not alone in policy making. Sources of crude oil and residual fuel oil were suddenly removed when OPEC countries announced a reduction in oil production and a ban on deliveries to certain countries including the United States and some close allies in an attempt to gain desired political results. This action not only produced restrictions on crude-oil imports, but more significantly threatened to completely curtail substantial quantities of required residual fuel oil.

The firms involved within the industry also persisted in rigid policies. A misapplication of marginal-cost concepts induced the adoption of product-dumping policies which added to the price-suppressing activities of the previously mentioned government policies. Numerous other policies complicated the picture. Measures adopted by the automotive industry increased petroleum-refining requirements, and new, hastily conceived policies of the Environmental Protection Agency presented rigid requirements which further heightened the capital intensity of the industry. All these interacting policies produced the pricing pattern indicated in Chapter 4. The effect of this price-suppressing activity and the government's assumption of price leadership in the oligopoly structure follow.

INTERVIEW RESULTS

The interview results and the postaudit evaluation of the industry's activity following the adoption of the mandatory import program as presented in Chapter 5 strongly suggest:

1. Return on investment during this period, particularly from 1967 through 1972, was sufficiently depressed to discourage construction of any totally new refinery facilities for investment reasons. While some facilities were constructed, reasons other than return on investment were responsible.

2. Uncertainty introduced by ecological considerations (i.e., plant location, and lack of knowledge regarding final

fuel-emissions requirements) combined with low return on investment temporarily halted construction.

3. A general pattern developed. Large companies definitely slowed totally new refinery construction and substituted a policy of balancing refinery facilities.

Certain refinery units, which were overbuilt initially, provided the opportunity to expand total capacity by raising the capacity of the rest of the refinery to the level of these units. Smaller firms continued to rely heavily on construction with used equipment to hold down investment costs. This action enabled them to show a consistently higher return on investment during this period than projects using totally new equipment. Some of the firms struggled with competitive pricing to the extent that they relied exclusively on the value of the import quota for their entire profit. Ironically there was a suggestion, after this price-suppressive time period ended, that the activities of the industry for the period 1967 through 1972 were normal conditions reflecting normal returns on investment. Several studies by the Chase Manhattan Bank have indicated a need for expanded capital requirements in petroleum refining. In addition, these studies also reported that return on investment for petroleum companies during this most seriously affected period of suppressed prices fell below the national average for manufacturing. Since the petroleum industry has, or is supposed to have, certain tax benefits, the return on investment should have been higher than the national average. In essence the effect of the price-suppressive rigidity, in all its complexity, surfaced as the energy crisis.

IMPLICATIONS

Several implications seem to present themselves from these observations.

Accounting Implications

The rigidities which surfaced as the result of the many policy interactions succeeded in holding prices fairly constant at a low level for about five years. Any stickiness of price directly affects the price-relative cost allocator; however, it was determined that the cost allocator had no bearing on the decisions of this time period since that cost allocator was not used in the planning departments of the industry. The effect of price rigidities coupled with the use of the price-relative cost allocator was presented in Chapter 2. The discussion of that chapter is still considered significant since planning personnel indicated a strong bias in favor of volume allocations.

Perhaps the real reason for the lack of a practical solution to the complex problem of joint cost allocation is the attempt by most persons to solve the problem in a single step or with as little additional effort as possible. Since Phase IV price controls require a cost justification for price increases, perhaps the time has come to try to agree on a uniform method of allocating cost to refined products. In a multifaceted problem, a multifaceted solution does not seem unreasonable. Volume appears to be a good allocator for processing costs. The volumes are predictable and the processing costs associated with basic refinery components can be closely approximated if they are not already known. The basic stumbling block has been and still is the allocation of the cost of the crude input. History has exposed the danger of attempting to propose a solution to this problem since any attempt invokes crossfire from several sectors of the academic community. All solutions previously proposed have been accepted with cynicism at one time or another by operating personnel. Despite these warnings the time has come to look more closely for a solution which can be generally accepted because the alternative has been a groping search by operating personnel and planners for a better way to determine cost differences for profit maximization.

The need becomes more urgent if, as has been suggested, petroleum as an energy source for the United States is, and will be, in short supply when demand and demand potential are considered. If the total quantity of petroleum requested significantly exceeds the quantity available, some indicator is required to direct available resources into the right ultimate product. In the author's opinion government has demonstrated a lack of ability to remain flexible in administering the needs and interests of the public. Policy rigidities have in large measure contributed to the initial problem. There is no current indication of any greater ability to handle these problems than the abilities demonstrated in the past when dealing with much simpler problems. In the author's opinion, free market forces could be capable of directing the resources better than regulatory policies. Industry accountants and engineers should acquaint the academic community with the specifics of the allocation problem in the refining industry. The three groups should then try to discover a more acceptable and longer-lived solution to the problem than has been presented historically.

Both the engineer and the accountant have traditional viewpoints which contain logical observations that can not be refuted. There should exist an allocation system which considers the different values of products inherent in the barrel of crude oil, the fact that technology can and has changed this slate of products, and that time is the variable. Time appears to be the critical variable either with a free-market system or a government-regulated one since it has been clearly demonstrated that government policies can cause a doubling of price within a relatively short time.

The industry was recently requested to provide the government with figures representing the loss associated with a change in production from gasoline to home-heating fuel. The industry ostensibly complied with this request despite repeated assurances by everyone that the cost of any single product within the refinery product mix cannot be separately determined. Quite obviously it had to be determined. An adjustment in prices of furnace fuels resulted from the figures presented to the government.

As mentioned previously in this chapter, there is also another accounting problem which should be given greater consideration. When replacement costs drastically exceed historic costs and large inventories of refined products or raw materials in place in the ground are involved, profit measurement is difficult. If prices are based on historic costs and no provision is made for the necessary inventories which must be held to assure future production, defense needs and delivery, insufficient funds will be generated to replace the inventory. LIFO is clearly an attempt to consider this problem. However, there has never before been a domestic problem of the magnitude which currently exists in the production and refining of petroleum products.

Economic Implications

The economic models presented in the literature need modification or they fail to explain the activities of an industry with all the outward appearance of an oligopoly. Because of government interference in the marketing mechanism, the oligopoly appears to be unable to set price, to limit entry into the area, to rid itself of nuisance factors, to prevent price competition over sustained periods of time, and generally to function as an oligopoly. One reason which suggests itself as a cause of this peculiar situation is the extensive knowledge that economists have concerning characteristics of an oligopoly and the fact that so many economists are employed by the government. Such an observation may be pure conjecture. It is not conjecture, however, that the interference has taken place. A model was presented in Chapter 3 (page 57) which attempted to explain in an ex post fashion the activity of the industry during the period under observation, using government intervention as a new factor in the model. Another model which was presented attempted to show the possible effects of government intervention in a more conventional approach. The activity of the industry during the period of study definitely indicates strong outside interference. In the author's opinion, the result of this interference has unarguably been to place upward rigidities on price and therefore seriously to diminish return on investment. The average return on investment for the industry has declined and was, at the end of this period, well below the national average for all manufacturers.

There are logical explanations for the firm's behavior prior to 1960, but the introduction of the import program signaled the beginning of a change in trend. The nation has already reaped part of the harvest of this arbitrary interference in a seemingly well-managed industry.

Suggestions have been made that refineries should be divorced from production and marketing facilities or that the government should take over all refining operations. Both of these suggestions appear unwarranted. The communication problems involved in the planning and control of balanced production, refining, and marketing are so complex that to further compound these problems seems at the least an unnecessary addition to the burden of the industry and at worst a potentially catastrophic event with severely damaging consequences. The assumption that the government could do as well with the refineries as had been done by the industry seems unwarranted from the facts. The nation can ill afford for the government to do worse.

The previously mentioned government interference in the marketing mechanism (see pages 145-150), attempted application of poorly understood marginal-cost concepts, and overt actions by foreign powers combined to produce an energy crisis. The actions of the United States Government regarding import policy and the government's assumption of the leadership role in industry pricing prior to the emergency by rather thinly veiled threats both combined to weaken the ability of the industry to solve its own problems. Had prices of critical products been higher and ecological restrictions and requirements been reasonably applied and clearly understood by all parties, there is every indication that the problem could have been met with less undesirable impact on the public. The industry now faces challenging problems of a planning control nature. In the future it will be faced with more pressing problems regarding product mix and will require better information for management decision-making purposes. The suggested accounting studies should help to provide that improved information.

APPENDIXES

APPENDIX A

CONTROLLED REFINING CAPACITY ON JANUARY 1, 1973, IN DESCENDING ORDER OF CAPACITY 1963 - 1973

Table A.1

Petroleum Companies Controlling at Least 200,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Exxon Co.	1,156,000	1,180,000	1,087,000	1,078,000	1,021,000	985,000	861,000	846,000	861,900	885,700	887,500
Texaco Inc.	1,109,500	1,109,500	1,029,500	960,00	925,000	925,000	805,000	790,000	785,000	785,000	750,000
Shell Oil Co.	1,082,600	1,059,600	1,058,500	942,900	875,800	810,500	786,500	727,000	726,000	682,300	652,600
Amoco Oil Co	1,022,000	958,000	996,400	896,100	885,300	835,300	737,800	684,200	680,200	678,500	661,700
Union Oil Co. of Calif.	969,900√	941,200	937,900	799,900	762,900	716,900	620,600	620,600	698,300	726,800	630,300
Mobil Oil Corp.	930,100	797,400	833,800*	856,400*	852,600*	736,200	680,700	693,000	669,300	674,900	665,300
Gulf Oil Co.	818,000	799,000	659,300	646,600	627,900	606,300	563,700	593,700	593,700	575,700	569,200
Atlantic Richfield Co.	772,800	768,000	670,000	703,000*	724,000	724,000	703,000	692,500	692,500	663,500	663,500
Sun Oil Co.	410,500	404,500	408,000	405,000	405,000	394,000	381,500	174,500	376,000*	385,000*	385,000*
Phillips Petroleum Co.	403,700	398,500	398,000	389,500	389,500	409,500	409,500	405,000	405,000	405,000	405,000
Ashland Oil, Inc.	350,300	344,300	316,500	289,500	261,500	260,500	245,500	219,500	204,000	197,000	192,200
Continental Oil Co.	285,000	283,000	272,500	276,300	273,300	276,300	240,800	253,500	249,000	245,900	216,950
Standard Oil Co. of Ohio	264,400	255,100	254,000	171,600	180,600	172,500	168,000	165,000	165,000	165,000	158,000
Cities Service Co.	240,000	281,000	281,000	261,000	241,000	241,000	241,000	255,300	255,300	255,300	255,300
Marathon Oil Co.	223,000	205,000	187,150	159,150	159,150	159,150	149,300	168,650	168,650	153,850	153,850

†Figures represent refinery capacity as controlled on January 1, 1973, irrespective of transfers of ownership. For this reason the increases indicated are true increases in total refinery capacity. Growth by individual firms through a policy of acquisition rather than constrcution will not appear to be growth but a constant refinery capacity.

√This total is a combination of barrels per calendar day and barrels per stream day since figures for just one category were not available.

*Barrels per stream day rather than barrels per calendar day.

Source:

Annual refinery numbers of the Oil and Gas Journal for the years presented.

Table A.2

Petroleum Companies Controlling Between 30,000 and 200,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
British Petroleum Co.	141,250	181,400	185,000	185,000	104,000	104,000	133,000	133,000	133,000	133,000	133,000
Getty Oil Co.	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000
Champlin Petroleum Co.	138,750	133,767	129,200*	90,000	87,000	87,000	87,000	84,180	81,680	81,680	80,180
Coastal States Petro Chem	130,000	133,000	133,000	133,000	85,500	80,000*	44,000	29,500	29,500*	27,500	29,000
Murphy Oil Co.	118,000	67,000	68,000	56,000	53,500	50,000	47,000	44,000	43,000	43,000	40,000
Clark Oil & Refining Co.	104,000	102,500	100,000	100,000	100,000	92,000	83,500	83,500	70,500	65,000	64,500
Amerada-Hess Corp.	98,500	98,500	98,500	98,500	95,700	93,800	90,900	90,900	88,600	89,850	89,850
Koch Refining Co.	96,500	87,700	87,000	77,300	77,300	62,300	62,300	62,300	62,300	62,300	43,200
Crown Central Petro Corp.	93,000	85,000	85,000	84,000	37,500	40,000	40,000	40,000	40,000	40,000	40,000
Tenneco Oil Co.	88,200	87,000	84,000	81,000	76,000	76,000	57,000	54,000	51,000	47,000	44,000
Skelly Oil Co.	67,000	67,000	67,000	65,000	65,000	65,000	65,000	48,000	47,000	45,500	60,500
Charter Oil Co.	62,055	62,055	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
CRA Inc. - Kansas	60,000	55,000	55,000	54,000	50,000	49,000	45,500	43,300	40,800	40,300	40,300
Texas City Ref., Inc.	60,000	60,000	60,000	50,000	50,000	52,500	50,000	40,000	40,000	40,000	34,000
Cosden Oil & Chem., Inc.	58,000	58,000	58,000	68,500	45,000	43,000	42,100	42,100	42,100	42,100	42,100
Suntide Oil Co., Tex.	51,000	51,000	50,000	49,000	49,000	54,000	54,000	54,000	54,000	53,000	53,000
Southwest Oil & Ref. Tex.	50,000	50,000	52,000*	52,000*	46,000	46,000	46,000	50,000*	50,000*	47,000	47,000
National Cooperative Refining Assoc. - Kan.	49,000	46,200	46,150	44,000	42,000	38,000	38,000	31.000	31,000	31,000	31,000
American Petrofina - Kan.	48,500	48,500	48,500	48,500	48,500	43,400	40,400	40,400	40,400	40,400	40,400
Chevron Asphalt Co.	46,900	39,200	35,900	35,900	35,900	33,600	33,600	32,300	30,800	30,800	30,800
Diamond Shamrock Co.	45,000	45,000	38,000	38,000	35,000	34,500	30,000	29,500	28,000	27,500	27,000
Douglas Oil Co. of Calif.	43,200	43,200	31,600	31,600	30,600	28,600	25,000	36,000	36,000	29,500	27,170
Tesoro Petro. Corp. (incl. Alaska)	41,500	35,600	27,910	28,650*	10,500	10,000	9,700	9,700	10,000	10,000	10,000
Husky Oil Co.	40,350	40,350	40,350	39,750	36,350	37,750	36,750	34,100	34,100	37,100	37,090
Lion Oil Co.	37,000	37,000	37,000	37,000	37,000	36,000	35,000	35,000	35,000	35,000	35,000
Apco Oil Corp.	37,000	37,000	37,000	37,000	29,000	29,000	29,500	29,500	37,000	37,000	37,000
Leonard Inc.	36,950	NR	29,000	29,000	27,750	27,750	27,750	27,750	27,750	27,750	27,750
Pasco Oil Co.	32,000	32,000	32,000	32,800	26,000	26,000	24,000	24,000	24,000	24,000	24,000

Table A.2 (continued)

Petroleum Companies Controlling Between 30,000 and 200,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Farmer's Union	30,000	30,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
Hawaiian Independent Ref.	30,000	---									

†Figures represent refinery capacity as controlled on January 1, 1973, irrespective of tranfers of ownership.

*Barrels per stream day rather than per calendar day.

Source:

Annual refinery numbers of the Oil and Gas Journal for the years presented.

Table A.3

Petroleum Companies Controlling Less Than 30,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Vickers Petroleum Corp.	29,500*	29,500*	29,000*	27,000*	27,000*	27,000*	25,000*	25,000*	25,000*	25,000*	25,000*
Delta Refining Co.	29,000	29,000	28,500	28,500	28,500	25,000	22,000	22,000	20,000	21,185	19,885
United Refining Co.	29,000	25,000	25,000	19,000	19,700	16,500	16,500	15,000	15,000	15,000	15,000
Powerine Oil Co.	28,500	28,500	28,500	28,500	27,000	20,000	20,000	20,000	19,000	14,000	14,000
Kerr McGee Corp.	28,500	28,500	42,000	41,000	40,000	38,000	38,500	33,500	31,500	31,000	31,000
Rock Island Refining Co.	27,329	27,000*	22,600	22,600	22,600	22,600	22,600	22,000	22,000	22,000	22,000
Sequoia Refining Co.	27,000	26,000	26,000	25,000*	25,000*	25,000*	25,000*	25,000*	1,300*	1,235	1,300
Toscopeto Corp.	26,500	25,500	25,500	22,000	22,000	22,000	22,000	22,000	20,000	20,000	16,000
Derby Refining Co.	25,500	25,500	25,300	24,800	23,800	23,400	21,500	21,500	21,500	21,500	21,500
Quaker State Oil Ref. Corp.	24,370	14,670	12,140	12,140	12,110	11,470	10,050	9,850	9,350	9,190	8,720
LaGloria Oil & Gas Co.	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Atlas Processing Co.	23,250	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500	17,500	17,500
Navajo Refining Co.	18,200	16,500	16,500	16,500	16,500	16,500	16,000	16,000	15,500	15,500	15,500
OKC Refining, Inc.	18,200	17,300	17,300	17,300	19,000	19,000	18,600	19,000	19,000	19,000	19,000
Midland Cooperatives	17,740	17,740	16,301	16,165	16,167	16,165	15,560	15,475	14,100	13.640	12,195
The Refinery Corp.	17,500	16,000*	12,000	11,500	11,500	10,000	10,000	10,000	10,000	10,000	10,000
Southland Oil Co.	17,400	15,100	13,200	8,000	8,000	8,500	8,500	8,500	8,500	8,300	8,300
Bay Refining Co.	17,000	17,000	17,000	15,000	15,000	15,000	15,000	22,000	22,000	23,000	22,000
Mohawk Petroleum Corp., Inc.	17,000	17,000	20,500	20,500	20,500	21,000	20,500	20,500	20,500	17,155	12,500
San Joaquin Refining Co.	17,000	10,000	---								
Witco Chemical Co., Inc.	16,350	25,350	24,950	26,750	19550	19,550	26,450	26,450	26,450	26,450	23,300
U.S. Oil & Refining Co.	16,000	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
Fletcher Oil & Refining Co.	15,200	14,000	12,000	12,000	12,000	14,000	14,000	14,000	9,615	9,615	9,615

Table A.3 (continued)

Petroleum Companies Controlling Less Than 30,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Edgington Oil Co.	15,000	15,000	15,000	15,000	16,000	16,000	16,000*	16,000*	16,000*	8,425	8,200
Hunt Oil Co.	15,000	14,750	14,000	8,200	9,000	9,000	9,000	9,000	9,000	9,000	8,000
Indiana Farm Bureau	15,000*	12,500	12,500	12,500	12,500	12,800	12,500	12,500	12,200	12,200	12,200
Pennzoil Co.	15,000	15,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Little America Refining Co.	14,500	14,500	13,500	13,500	13,500	---					
Macmillan Ring-Free Oil Co.	14,500*	15,000*	14,400	14,400	14,400	14,400	14,400	14,400	14,400	13,400	13,700
West Coast Oil Co.	12,700	13,000	11,750	10,000	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Alabama Refining Co.	12,600	12,500	13,000	13,000	12,500	10,000	---				
Beacon Oil Co.	12,000	11,375	11,375	11,375	11,375	11,375	11,375	10,950	10,000	10,000	10,000
Fort Worth Refining Co.	12,000	12,000	12,000	12,000	12,000	12,000	10,500	10,500	---		
Kern County Refining Co.	12,000	12,000	12,000	12,000	12,000	12,000	12,000	---			
Oseceda Refining Co.	10,000*	8,000*	8,000	5,000	5,000	5,000	5,000*	5,000*	5,000*	5,000	5,000
Good Hope Refining Co.	9,000	9,000	10,000*	8,600*	6,500	---					
Pride Refining Inc.	9,000*	8,500	8,500	5,500	5,500	5,500	5,300	5,000	3,230	3,230	2,900
Union Texas Petroleum	9,000	9,000	8,150	8,150	8,150	8,150	8,150	8,150	8,150	7,600	7,600
Sunland Refining Corp.	8,500	8,500	8,350	5,350	5,350	5,350	5,350	5,350	5,350	4,500	4,500
Carson Oil Co.	6,900	6,900	7,000*	---							
Caribou's Four Corners, Inc.	6,500	6,500	4,970	5,020	4,490	5,000	4,500*	3,200	3,000*	---	
Newhall Refining Co., Inc.	6,500*	6,500*	6,500	6,500*	6,500*	6,500*	6,200	4,500	4,000	3,400	3,400
Cotton Valley Solvents	6,442	7,600	6,201	8,000*	8,000*	7,600	7,600	7,600	7,600	4,750	4,750
Crystal Refining Co.	6,200	6,200	6,200	6,200	3,300	6,200	6,200	6,200	6,200	6,200	6,200
Lajet, Inc.	6,000	6,000*	6,000	---							
Tonkawa Refining Co.	6,000	6,000	6,000	6,000	6,000	7,500	---				

Table A.3 (continued)

Petroleum Companies Controlling Less Than 30,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Laketon Asphalt Refining	5,500	6,000*	6,000*	6,000	6,000	5,500	5,000*	4,500	4,500	4,500	4,500
American Gilsonite Co.	5,450	5,450	5,450	5,600	5,400	5,400	6,050*	6,050*	6,050*	5,050*	---
Plateau Inc.	5,100	5,100	5,100	4,100	4,100	2,400	2,300	2,500	2,400	2,300	2,300
Adobe Refining Co.	5,000	5,500	5,500	5,500	5,000	5,000	2,500	2,500	2,500	2,500	3,000
Cross Oil & Refining Co.	5,000	5,000	5,000	5,000	5,000	3,350	3,830	3,600	3,500	3,600	3,800
Longview Refining Co.	5,000	5,000	5,000*	5,000*	5,500	4,500	---				
Lunday-Thagard Oil Co.	5,000	5,000	3,600	2,600	4,000*	---					
North American Petro. Corp.	5,000	5,000*	5,000	4,300	4,300	3,800	3,600	3,600	5,700	5,700	5,700
Seminole Asphalt Refining Co.	5,000	3,000	3,100	3,100	3,100	3,100	3,000	3,000	3,000	2,950	2,850
Westland Oil Co.	5,000*	3,300	5,000	5,000	5,000	5,000	5,000	2,500	2,500	2,400	2,500
Big West Oil Co.	4,827	4,384	6,000	5,700	5,700	2,850	2,850	2,850	2,850	2,700	2,850
Lakeside Refining Co.	4,750	4,000	4,000	4,000*	4,000	4,000*	4,000*	4,000*	4,000	4,275	4,275
Farmariss Oil Corp.	4,500*	4,420	4,420	4.420	4,420	4,420	1,970	1,675	1,675	1,675	1,675
Allied Materials Corp.	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,000	4,000	4,000	4,000
Sound Refining Co.	4,300	4,500	4,500	4,500	4,500	2,850	---				
Evangeline Refining Co.	4,000	4,000*	4,500	3,600	4,000	2,000	2,000	2,000	2,000	2,315	2,000
Westro Refining Co.	3,982	3,500	3,900	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800
Gladieux Refining, Inc.	3,500	3,000	6,500	3,000	3,500*	3,000*	3,000*	3,000*	3,500*	2,850	2,470
Bayou State Oil Corp.	3,500	3,250*	1,500*	1,000	1,000	920	800	800	800	800	800
Howell Hydrocarbons	3,000	3,300	3,300	3,300	3,300	3,500*	4,500*	3,500*	3,000	3,325	3,325
Mid American Refining Co.	3,000	3,000	3,000	3,200	2,900	3,000	2,950	2,950	2,800	2,850	2,850
Petroleum Refining Co.	3,000*	3,000*	3,000*	3,000*	3,000*	3,000	3,000	3,000	3,000	2,500	2,500
Vulcan Asphalt Refining Co.	3,000	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,200	2,200	2,200

Table A.3 (continued)

Petroleum Companies Controlling Less Than 30,000 Barrels of Daily Refining Capacity on January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Canal Refining Co.	2,500	2,500	2,500	2,400	1,700	1,700	1,700	1,700	1,700	1,700	1,700
Spruce Oil Corp.	2,500	2,500	2,500	2,200	2,800	2,800	2,800	2,800	2,800	2,800	2,800
Calument Refining Co.	2,400	2,200	2,200	2,400*	2,400	2,000	1,900	1,900	1,900	1,900	1,900
Young Refining Co.	2,300	2,000	2,000*	4,000*	3,000*	2,500*	2,000	2,000	1,500	2,000	1,500
Edington Oxnard Refinery	2,500*	2,250	2,500	2,500	2,550*	2,500*	2,500	2,500	2,500	700	2,375
Warrier Asphalt Co.	2,200	2,200	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,600
Wolfshead Oil Refining Co.	2,050	2,050	2,500	2,020	2,020	2,020	2,020	2,020	2,020	2,150	2,150
Eddy Refining Co.	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Texas Asphalt & Refining Co.	2,000	2,500	2,100	2,000	2,000	2,000*	4,750	4,750	4,750	4,750	4,750
Berry Petroleum Co.	1,530	3,500	3,500	3,500	3,500	3,300	2,830	3,300	3,300	3,300	3,325
Summerset Refinery, Inc.	1,500	1,500	1,500	1,500	1,500	2,925	2,850	2,850	2,850	2,850	2,850
Three Rivers Refining Co.	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Wireback Oil Co.	1,500	1,500*	1,200	1,200	1,200	1,200*	1,200	1,200	1,200	1,200	1,200
Flint Chemical Co.	1,200	1,200	1,200	1,000	1,000	1,000	800	800	800	800	800
Thriftway Oil Co.	1,200	---									
Jetfuel Refining Co.	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Yetter Oil Co.	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	950
Sage Creek Refining Co.	200*	500*	500	500	500	500	---				
Mountaineer Refining Co.	50	300	200*	200*	---						

†Figures represent refinery capacity as controlled on January 1, 1973, irrespective of transfers of ownership.

*Barrels per stream day rather than barrels per calendar day.

Source:

Annual refinery numbers of the <u>Oil and Gas Journal</u> for the years presented.

Table A.4

Refining Capacity No Longer Utilized
by January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
American Oil Co. - Ark.	---	30,000	43,600	43,600	43,600	43,600	39,400	38,700	38,700	38,700	38,700
Pennsylvania Refining Co.	Δ	1,350	1,600	1,430	1,260	1,375	1,375	1,375	1,850	1,350	1,350
Diamond Asphalt Co.	Δ	1,100	1,500*	1,500*	1,500*	1,500*	2,500*	2,500*	2,500	1,000	1,000
Morrison Refining Co.	Δ	700	700	700	700	700	---				
Utility Refining Co.		---	8,000	8,000	8,000	8,100	8,200	7,125	7,125	7,125	5,000
Monarch Refining Co.		---	3,500	3,500	3,300	2,500	2,500	2,500	2,900	4,000	4,000
Anderson Refining Corp.		---	2,400	2,400	2,400	1,500	1,500	1,500	1,500	1,250	1,200
Newton Petroleum Enterprise		---	500	800	---						
American Oil Co. - Kan.			---	30,800	30,800	30,800	30,800	30,600	30,600	30,600	30,600
Golden Eagle Refining Inc.			---	9,500	9,500	9,500	9,000	9,000	9,000	9,500	8,000
Howell Refining Corp.			---	8,100	8,100	10,000	6,500*	4,000*	4,000*	4,750	4,750
Bayou Refining Co., Inc.			---	7,300	7,200	7,200	---				
Southern Minerals Corp.			---	5,000*	5,000*	---					
R. J. Oil & Refinery Co., Inc.			---	4,800	4,500	4,900	4,700	4,500	4,500	4,500	4,800
Ida Gasoline Co.			---	950	950	950	950	950	600	600	600
Empire State Oil Co.				---	5,000*	5,000*	5,000	5,000	5,000	5,000	4,275
Naph Sol Refinery					---	10,000	10,000	10,000	10,000	9,500	10,000
Nevada Refining, Inc.					---	1,500*	---				
Pana Refining Co.					---	6,500	6,500	5,500	5,500	5,000	5,000
Lubio Oil & Refining Co.					---	5,000	5,000	3,500	---	1,500	1,500
Delta Terminal Co.					---	4,000*	omitted	4,000*	---		
Tydall Co.					---	2,000	2,000	2,000	2,000	1,900	1,900
Rado Refining Co.					---	1,500	1,500	1,500	1,500	1,500	1,425
Lamar Refining					---	1,050	1,000	1,000	---		
Petroleum Industries						---	2,000	2,000*	2,000	2,000	1,900
Refinery Sales						---	2,000	---			

Table A.4 (continued)

Refining Capacity No Longer Utilized by January 1, 1973†

	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963
Vickers Refinery								---	15,000	15,000	15,000
Premier Oil Co.								---	13,900	15,300	19,000
Berry Refining Co.								---	13,000	13,800	13,300
Petroleum Specialties								---	5,000	6,000	6,000
Oriental Refining								---	4,215	4,215	4,215
American Bitumals - Wash.								---	3,200	3,200	3,200
Danaho Refining Co.									---	9,500	9,500
Socal Oil & Refining Co.									---	4,750	5,000
Wyandott Chemical									---	2,380	2,380
Bryson Pipeline									---	2,000	2,000
Waskom Natural Gas									---	2,000	2,000
North Star Refining Co.									---	700	---
C. & H. Refining Co.									---	200	200
Pontiac Eastern										---	16,500
Kent Distribution										---	3,500
Advance Refining Co.										---	3,000
Great Western										---	2,500
Trumball Asphalt Co.										---	2,000

†Figures represent refinery capacity as controlled on January 1, 1973, irrespective of transfers of ownership.

ΔRefinery shut down but operable.

*Barrels per stream day rather than barrels per calendar day.

Source:

Annual refinery numbers of the Oil and Gas Journal for the years presented.

APPENDIX B

APPLICATION OF A t TEST FOR SLOPES OF REGRESSION LINES TO OKLAHOMA REGULAR GASOLINE PRICES

Part I of this appendix presents the formulas to be utilized in the t tests, and will develop modifications which allow utilization of the regression table. Part II is devoted to testing the appropriateness of price-level adjustments and Part III tests the original price data before and after the introduction of the oil-import changes in March, 1959.

Part I. The following equations are used.[1]

B.1 $$s^2yxp = \frac{(n-2)s^2y_1x + (n_2-2)s^2y_2x}{n_1 + n_2 - 4}$$

B.2a $$s^2y_1x = \frac{n_1 - 1}{n_2 - 2}\,(sy_1{}^2 - b_1{}^2sx_1{}^2)$$

B.2b $$s^2y_2x = \frac{n_2 - 1}{n_2 - 2}\,(sy_2{}^2 - b_2{}^2sx_2{}^2)$$

B.3 $$t = \frac{b_1 - b_2}{syxp\sqrt{\dfrac{1}{(n_1-1)\,sx_1{}^2} + \dfrac{1}{(n_2-1)\,sx_2{}^2}}}$$

Equation B.3 is designed to test the null hypothesis $H: B_1 - B_2 = 0$. This hypothesis should be rejected if t is significantly different from zero ($df = n_1 + n_2 - 4$).

The following table is utilized to provide simplification of the computation when computer-generated least-squares regression output is the input to the t test.[2]

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[1]Wilfred J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (3rd ed.; New York: McGraw Hill, Inc., 1969), pp. 208-09.

[2]James E. Wert, Charles D. Neidt, and J. Stanley Ahmann, Statistical Methods in Educational and Psychological Research (New York: Appleton - Century - Crofts, Inc., 1954) p. 236.

Table B.1

General Values on the Regression Table

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Regression	1	$\frac{(\Sigma xy)^2}{\Sigma x^2}$	$\frac{(\Sigma xy)^2}{\Sigma x^2}$
Residuals	n-2	$\Sigma y^2 - \frac{(\Sigma xy)^2}{\Sigma x^2}$	$\frac{\Sigma y^2 - \frac{(\Sigma xy)^2}{\Sigma x^2}}{n-2}$
Totals	n-1	Σy^2	$\frac{\Sigma y^2}{n-1}$

Given $b_1 = \frac{\Sigma xy}{\Sigma x^2}$ and $(n-1)\, s_{x_1}^2 = \Sigma x_1^2$

then:

$$\frac{(\Sigma xy)^2}{\Sigma x^2} = \text{S. S. regression} \qquad \text{from table}$$

$$b_1 \,\Sigma xy = \text{S. S. regression} \qquad \text{by substitution}$$

$$\Sigma xy = \frac{\text{S. S. regression}}{b_1}$$

$$(\Sigma xy)^2 = \frac{(\text{S. S. regression})^2}{b_1^2}$$

and: (Σx_1^2) S. S. regression $= (\Sigma xy)^2$

$$(\Sigma x_1^2)\ \text{S. S. regression} = \frac{(\text{S. S. regr})^2}{b_1^2} \qquad \text{by substitution}$$

$$\Sigma x_1^2 = \frac{(\text{S.S. regr})^2}{b_1^2} \cdot \frac{1}{\text{S.S. regr.}}$$

$$\Sigma x_1^2 = \frac{\text{S.S. regr.}}{b_1^2}$$

and:

$$(n - 1)\ s_{x_1}{}^2 = \Sigma x_1{}^2$$

$$(n - 1)\ s_{x_1}{}^2 = \frac{\text{S.S. regr.}}{b_1{}^2} \quad \text{by substitution}$$

$$s_{x_1}{}^2 = \frac{\text{S.S. regr.}}{(n-1)\ b_1{}^2}$$

Given: the previous formulas and the Mean Square Residual definition from the table, prove that the cross variance

$$s^2{}_{y_1x} = \text{Mean Square Residual}$$

$$s^2{}_{y_1x} = \frac{n-1}{n-2}\ (s_{y_1}{}^2 - b^2 s_{x_1}{}^2) \qquad \text{formula B.2a}$$

$$= \frac{1}{n-2}\ [(n-1)s_{y_1}{}^2 - (n-1)\ b^2 s_{x_1}{}^2]$$

$$= \frac{1}{n-2}\ [\Sigma y_1{}^2 - (n-1)b^2\ \frac{\text{S.S. regr.}}{(n-1)\ b^2}] \quad \text{by substitution}$$

$$= \frac{1}{n-2}\ [\Sigma y_1{}^2 - (\text{S.S. regr.})_1]$$

$$= \frac{1}{n-2}\ [\Sigma y_1{}^2 - \frac{(\Sigma xy)^2}{\Sigma x_1{}^2}] \quad \text{by substitution}$$

$$s^2{}_{y_1s} = \frac{\Sigma y_1{}^2 - \frac{(\Sigma xy)^2}{\Sigma x^2}}{n - 2}$$

$$s^2{}_{y_1x} = (\text{mean square residual}), \quad \text{by definition}$$

Given formula B.1:

$$s^2yxp = \frac{(n-2)\ s^2y_1x + (n-2)\ s^2y_2x}{n_1 + n_2 - 4}$$

Simplify if s^2y_1x = mean square residual

$$s^2yxp = \frac{(n-2)\ (\text{M.S. resid.})_1 + (n-2)\ (\text{M.S. resid})_2}{n_1 + n_2 - 4}$$

$$= \frac{(\text{S.S. resid.})_1 + (\text{S.S. resid.})_2}{n_1 + n_2 - 4}$$

The following formulas are simplified versions of previous formulas needed for the t test:

B.4 $$sx_1^{\ 2} = \frac{\text{S.S. regr.}}{(n-1)\ b_1^{\ 2}}$$

B.5 $$s^2ysp = \frac{(\text{S.S. resid.})_1 + (\text{S.S. resid.})_2}{n_1 + n_2 - 4}$$

Part II. Two separate t tests must be applied to test the appropriateness of price-level adjustments prior to the analysis of price data when there is an indication of price suppression. Two tests are required since it is suspected that a significant change has taken place between the two sets of data. The pre-1965 data sets (Tables B.2 and B.3 will be tested in section IIa and the post-1964 data sets will be tested in section IIb.

IIa. The tabulated results of the least-squares regression for the pre-1965 data follows:

Table B.2

Average Oklahoma Refinery Prices for Regular Grade Gasoline
as a Percentage of the Base Month's* Price
Pre-1965 †

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1955												
X	--	--	--	--	--	--	--	--	33	34	35	36
Original Price	--	--	--	--	--	--	--	--	11.25	11.25	11.25	11.25
% of Base Month's Price	--	---	--	--	--	--	--	--	100.0	100.0	100.0	100.0
1956												
X	37	38	39	40	41	42	43	44	45	46	47	48
Original Price	11.25	11.25	11.33	11.38	11.73	11.88	11.88	11.88	11.88	11.76	11.63	11.63
% of Base Month's Price	100.0	100.0	100.7	101.2	104.3	105.6	105.6	105.6	105.6	104.5	103.4	103.4
1957												
X	49	50	51	52	53	54	55	56	57	58	59	60
Original Price	12.27	12.63	12.63	12.63	12.63	12.41	12.01	12.00	12.11	12.13	12.13	12.13
% of Base Month's Price	109.1	112.3	112.3	112.3	112.3	110.3	106.8	106.7	107.6	107.8	107.8	107.8
1958												
X	61	62	63	64	65	66	67	68	69	70	71	72
Origial Price	12.38	12.28	12.15	12.00	12.00	12.25	12.57	12.88	12.88	12.76	12.50	12.50
% of Base Month's Price	110.0	109.2	108.0	106.7	106.7	108.9	111.7	114.5	114.5	113.4	111.1	111.1
1959												
X	73	74	75	76	77	78	79	80	81	82	83	84
Original Price	12.48	12.38	12.57	12.75	12.63	12.32	12.08	12.62	12.55	12.00	11.86	11.56
% of Base Month's Price	110.9	110.0	111.7	113.3	112.3	109.5	107.4	112.2	111.6	106.7	105.4	102.8
1960												
X	85	86	87	88	89	90	91	92	93	94	95	96
Original Price	11.15	11.34	11.82	12.00	11.60	12.17	12.73	13.30	13.38	13.38	13.38	13.38
% of Base Month's Price	99.1	100.8	105.1	106.7	103.1	108.2	113.2	118.2	118.9	118.9	118.9	118.9
1961												
X	97	98	99	100	101	102	103	104	105	106	107	108
Original Price	13.38	13.38	13.38	13.38	12.99	13.13	13.13	12.92	11.88	11.88	12.00	12.22
% of Base Month's Price	118.9	118.9	118.9	118.9	115.5	116.7	116.7	114.8	105.6	105.6	106.7	108.6
1962												
X	109	110	111	112	113	114	115	116	117	118	119	120
Original Price	12.34	11.26	10.84	12.64	12.91	13.00	13.00	13.00	13.00	13.00	13.00	12.77
% of Base Month's Price	109.7	100.1	96.4	112.4	114.8	115.6	115.6	115.6	115.6	115.6	115.6	113.5

Table B.2

Average Oklahoma Refinery Prices for Regular-Grade Gasoline as a Percentage of the Base Month's* Price Pre-1965 + (continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1963												
X	121	122	123	124	125	126	127	128	129	130	131	132
Original Price	12.10	11.64	12.00	12.48	12.75	13.06	12.94	12.19	11.8	12.23	11.00	11.57
% of Base Month's Price	107.6	103.5	106.7	110.9	113.3	116.1	115.0	108.4	104.9	108.7	97.8	102.8
1964												
X	133	134	135	136	137	138	139	140	141	142	143	---
Original Price	11.63	11.63	11.51	11.41	11.63	11.63	11.63	11.63	10.83	11.31	12.04	---
% of Base Month's Price	103.4	103.4	102.3	101.4	103.4	103.4	103.4	103.4	96.3	100.5	107.0	___

*September 1955

†From September 1955 through November 1964

Table B.3

Wholesale Price Index (All Commodities) as Prepared by the United States Department of Labor, as Adjusted to the 1947-49 Base Period, and Presented as a Percentage of the Base Month's* Index Value.
Pre-1965 †

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1955												
X	--	--	--	--	--	--	--	--	33	34	35	36
Original Index Value	--	--	--	--	--	--	--	--	111.7	111.6	111.2	111.3
Value as Adjusted to 47-49 Base	--	--	--	--	--	--	--	--	111.7	111.6	111.2	111.3
% of Base Month's Index Value	--	--	--	--	--	--	--	--	100.0	99.9	99.6	99.6
1956												
X	37	38	39	40	41	42	43	44	45	46	47	48
Original Index Value	111.9	112.4	112.8	113.6	114.4	114.2	114.0	114.7	115.5	115.6	115.9	116.3
Value as Adjusted to 47-49 Base	111.9	112.4	112.8	113.6	114.4	114.2	114.0	114.7	115.5	115.6	115.9	116.3
% of Base Month's Index Value	100.2	100.6	101.0	101.7	102.4	102.2	102.1	102.7	103.4	103.5	103.8	104.1
1957												
X	49	50	51	52	53	54	55	56	57	58	59	60
Original Index Value	116.9	117.0	116.9	117.2	117.1	117.4	118.2	118.4	118.0	117.8	118.1	118.5
Value as Adjusted to 47-49 Base	116.9	117.0	116.9	117.2	117.1	117.4	118.2	118.4	118.0	117.8	118.1	118.5
% of Base Month's Index Value	104.7	104.7	104.7	104.9	104.8	105.1	105.8	106.0	105.6	105.5	105.7	106.1
1958												
X	61	62	63	64	65	66	67	68	69	70	71	72
Original Index Value	118.9	119.0	119.7	119.3	119.5	119.2	119.2	119.1	119.1	119.0	119.2	119.2
Value as Adjusted to 47-49 Base	118.9	119.0	119.7	119.3	119.5	119.2	119.2	119.1	119.1	119.0	119.2	119.2
% of Base Month's Index Value	106.4	106.5	107.2	106.8	107.0	106.7	106.7	106.6	106.6	106.5	106.7	106.7
1959												
X	73	74	75	76	77	78	79	80	81	82	83	84
Original Index Value	119.5	119.5	119.6	120.0	119.9	119.7	119.5	119.1	119.7	119.1	118.9	118.9
Value as Adjusted to 47-49 Base	119.5	119.5	119.6	120.0	119.9	119.7	119.5	119.1	119.7	119.1	118.9	118.9
% of Base Month's Index Value	107.3	107.0	107.1	107.4	107.3	107.2	107.0	106.6	107.2	106.6	106.4	106.4
1960												
X	85	86	87	88	89	90	91	92	93	94	95	96
Original Index Value	119.3	119.3	120.0	120.0	119.7	119.5	119.7	119.2	119.2	119.6	119.6	119.5
Value as Adjusted to 47-49 Base	119.3	119.3	120.0	120.0	119.7	119.5	119.7	119.2	119.2	119.6	119.6	119.5
% of Base Month's Index Value	106.8	106.8	107.4	107.4	107.2	107.0	107.2	106.7	106.7	107.1	107.1	107.0
1961												
X	97	98	99	100	101	102	103	104	105	106	107	108
Original Index Value	119.9	101.0	101.0	100.5	100.0	99.5	99.9	100.0	100.0	100.0	100.0	100.4
Value as Adjusted to 47-49 Base	119.9	120.0	120.0	119.4	118.8	118.2	118.7	119.0	118.8	118.8	118.8	119.3
% of Base Month's Index Value	107.3	107.4	107.4	106.9	106.3	105.8	106.2	106.5	106.3	106.3	106.3	106.8

Table B.3
Wholesale Price index (All Commodities) as Prepared by the United States Department of Labor, as Adjusted to the 1947-49 Base Period, and Presented as a Percentage of the Base Month's* Index Value.
Pre-1965 † (continued)

	Jan	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1962												
X	109	110	111	112	113	114	115	116	117	118	119	120
Original Index Value	100.8	100.7	100.7	100.4	100.2	110.0	100.4	100.5	101.2	100.6	100.7	100.4
Value as Adjusted to 47-49 Base	119.7	119.6	119.6	119.3	119.0	130.7	119.3	119.4	120.2	119.5	119.6	119.3
% of Base Month's Index Value	107.2	107.1	107.1	106.8	106.6	117.0	106.8	106.9	107.6	107.0	107.1	106.8
1963												
X	121	122	123	124	125	126	127	128	129	130	131	132
Original Index Value	100.5	100.2	99.9	99.7	100.0	100.3	100.6	100.4	100.3	100.5	100.7	100.3
Value as Adjusted to 47-49 Base	119.4	119.0	118.7	118.4	118.8	119.1	119.5	119.3	119.1	119.4	119.6	119.1
% of Base Month's Index Value	106.9	106.6	106.2	106.0	106.3	106.7	107.0	106.8	106.7	106.9	107.1	106.7
1964												
X	133	134	135	136	137	138	139	140	141	142	143	--
Original Index Value	101.0	100.5	100.4	100.3	100.1	100.0	100.4	100.3	100.7	100.8	100.7	- -
Value as Adjusted to 47-49 Base	120.0	119.4	119.3	119.1	118.9	118.8	119.3	119.1	119.6	119.7	119.6	--
% of Base Month's Index Value	107.4	106.9	106.8	106.7	106.5	106.3	106.8	106.7	107.1	107.2	107.1	--

*September 1955

†From September 1955 through November 1964

Table B.4

Regression Table for Wholesale Price Index
as a Percentage of the Base Month Index
September 1955 to October 1964

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Regression	207.945	1	207.945
Residual	324.055	109	2.97928
Totals	532	110	4.83636

F = 69.9449

Coefficient of Determination = .390874

Coefficient of Correlation = .625199

Standard Error of Estimate = 1.72423

n_1 = 111

When the volume of x is 33 then y is 103.661

When the volume of x is 143 then y is 108.36

Coefficients

$B_{(0)}$ = 102.251

$B_{(1)}$ = .0427172

Table B.5

Regression Table for Wholesale Gasoline Prices as a Percentage of the Base Month Price September 1955 to November 1964

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Regression	46.5005	1	46.5005
Residual	3744.5	109	34.3532
Totals	3741	110	34.4636

F = 1.3536

Coefficient of Determination = .012266

Coefficient of Correlation = .110752

Standard error of estimate 5.86116

$n_1 = 111$

When the value of x is 33 then y is 107.465

When the value of x is 143 then y is 109.687

Coefficients

$B_{(0)} = 106.798$

$B_{(1)} = .0202$

$sx_1^2 = 1036.0109$

$sx_2^2 = 1036.1073$

$s^2yxp = 18.663096$

$syxp = 4.32008$

$t = 1.241$

With 218 degress of freedom t is not significantly different from zero and therefore the slopes of the regression curves must be accepted as similar.

II b. The tabulated results of the least-squares regression for the post-1964 data (Tables B.8 and B.9) covering the relative comparison of Oklahoma wholesale gasoline prices with corresponding comparable percentages of the wholesale price index (all commodities) follow:

Table B.6

Regression Table for Wholesale-Price-Level Indexes as a Percentage of the Base Month Index December 1964 to December 1972

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Regression	6546.79	1	6546.79
Residual	285.215	95	3.00226
Totals	6832	96	71.16667

F = 2180.62

Coefficient of Determination = .958253

Coefficient of Correlation = .978904

Standard Error of Estimate = 1.7327

n_1 = 97

When the value of x is 144 then y is 105.463

When the value of x is 240 then y is 133.63

Coefficients

$B_{(0)}$ = 63.2124

$B_{(1)}$ = .293407

Table B.7

Regression Table for Oklahoma Wholesale Gasoline Prices as a Percentage of the Base Month Price December 1964 to December 1972

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Regression	406.647	1	406.647
Residual	734.353	95	7.73003
Totals	1141	96	11.88542

F = 52.6062

Coefficient of Determination = .356396

Coefficient of Correlation = .596989

n_2 = 97

When the value of x is 144 then y is 106.903

When the value of x is 240 then y is 113.523

Coefficients

$B(0)$ = 95.9733

$B(0)$ = .0731249

$s_{x_1}^2$ = 792.16669

$s_{x_2}^2$ = 792.17277

s^2_{yxp} = 5.3661473

s_{yxp} = 2.31649

t = 18.572906

With 190 degrees of freedom t is definitely different from zero at the 99 percent confidence level and therefore

Table B.8

Average Oklahoma Refinery Prices for Regular-Grade Gasoline
as a Percentage of the Base Month's* Price
Post-1964 †

	Jan	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1964												
X	--	--	--	--	--	--	--	--	--	--	--	144
Original Price	--	--	--	--	--	--	--	--	--	--	--	12.25
% of Base Month's Price	--	--	--	--	--	--	--	--	--	--	--	108.9
1965												
X	145	146	147	148	149	150	151	152	153	154	155	156
Original Price	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.08	11.95	12.25	12.25	12.25
% of Base Month's Price	108.9	108.9	108.9	108.9	108.9	108.9	108.9	107.4	106.2	108.9	108.9	108.9
1966												
X	157	158	159	160	161	162	163	164	165	166	167	168
Original Price	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25
% of Base Month's Price	108.9	108.9	108.9	108.9	108.9	108.9	108.9	108.9	108.9	108.9	108.9	108.9
1967												
X	169	170	171	172	173	174	175	176	177	178	179	180
Original Price	12.25	12.37	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.52
% of Base Month's Price	108.9	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110 0	110.0	110.0	111.3
1968												
X	181	182	183	184	185	186	187	188	189	190	191	192
Original Price	11.33	11.59	11.90	11.99	11.62	11.88	11.88	11.88	11.88	11.69	11.63	11.64
% of Base Month's Price	100.7	103.0	105.8	106.6	103.3	105.6	105.6	105.6	105.6	103.9	103.4	103.5
1969												
X	193	194	195	196	197	198	199	200	201	202	203	204
Original Price	11.77	11.75	12.48	12.44	12.29	12.22	12.09	12.28	12.18	12.17	12.25	12.29
% of Base Month's Price	104.6	104.4	110.9	110.6	109.2	108.6	107.5	109.2	108.3	108.2	108.9	109.2
1970												
X	205	206	207	208	209	210	211	212	213	214	215	216
Original Price	12.10	12.09	12.00	12.69	12.67	12.54	12.70	12.71	12.66	12.66	12.73	13.24
% of Base Month's Price	107.6	107.5	106.7	112.8	112.6	111.5	112.9	113.0	112.5	112.5	113.2	117.7
1971												
X	217	218	219	220	221	222	223	224	225	226	227	228
Original Price	13.16	12.95	12.80	12.49	13.13	12.98	12.88	12.88	12.81	12.75	12.75	12.75
% of Base Month's Price	117.0	115.1	113.8	111.9	116.7	115.4	114.5	114.5	113.9	113.3	113.3	113.3

Table B.8

Average Oklahoma Refinery Prices for Regular-Grade Gasoline as a Percentage of the Base Month's* Prices Post-1964 † (continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1972												
X	229	230	231	232	233	234	235	236	237	238	239	240
Original Price	12.73	12.62	12.67	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88
% of Base Month's Price	113.2	112.2	112.6	114.5	114.5	114.5	114.5	114.5	114.5	114.5	114.5	114.5

*September 1955

†From December 1964 through December 1972

Table B.9

Wholesale Price Index (All Commodities) as Prepared by the United States Department of Labor, as Adjusted to the 1947-49 Base Period, and Presented as a Percentage of the Base Month's* Index Value Post-1964 †

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1964												
X	--	--	--	--	--	--	--	--	--	--	--	144
Original Index Value	--	--	--	--	--	--	--	--	--	--	--	100.7
Value as Adjusted to 47-49 Base	--	--	--	--	--	--	--	--	--	--	--	119.6
% of Base Month's Index Value	--	--	--	--	--	--	--	--	--	--	--	107.1
1965												
X	145	146	147	148	149	150	151	152	153	154	155	156
Original Index Value	101.0	101.2	101.3	101.7	102.1	102.8	102.9	102.9	103.0	103.1	103.5	104.1
Value as Adjusted to 47-49 Base	120.0	120.2	120.3	120.8	121.3	122.1	122.2	122.2	122.4	122.5	122.9	123.7
% of Base Month's Index Value	107.4	107.6	107.7	108.2	108.6	109.3	109.4	109.4	109.5	109.6	110.1	110.7
1966												
X	157	158	159	160	161	162	163	164	165	166	167	168
Original Index Value	104.6	105.4	105.4	105.5	105.6	105.7	106.4	106.1	106.8	106.2	105.9	105.9
Value as Adjusted to 47-49 Base	124.3	125.2	125.2	125.3	125.4	125.6	126.4	126.0	126.9	126.2	125.8	125.8
% of Base Month's Index Value	111.2	112.1	112.1	112.2	112.3	112.4	113.2	112.8	113.6	112.9	112.6	112.6
1967												
X	169	170	171	172	173	174	175	176	177	178	179	180
Original Index Value	106.2	106.0	105.7	105.3	105.8	106.3	106.5	106.1	106.2	106.1	106.2	106.8
Value as Adjusted to 47-49 Base	126.2	125.9	125.6	125.1	125.7	126.3	126.5	126.0	126.2	126.0	126.2	126.9
% of Base Month's Index Value	112.9	112.7	112.4	112.0	112.5	113.0	113.3	112.8	112.9	112.8	112.9	113.6
1968												
X	181	182	183	184	185	186	187	188	189	190	191	192
Original Index Value	107.2	108.0	108.2	108.3	108.5	108.7	109.1	108.7	109.1	109.1	109.6	109.8
Value as Adjusted to 47-49 Base	127.3	128.3	128.5	128.6	128.9	129.1	129.6	129.1	129.6	129.6	130.2	130.4
% of Base Month's Index Value	114.0	114.9	115.1	115.2	115.4	115.6	116.0	115.6	116.0	116.0	116.6	116.8
1969												
X	193	194	195	196	197	198	199	200	201	202	203	204
Original Index Value	110.7	111.1	111.7	111.9	112.8	113.2	113.3	113.4	113.6	114.0	114.7	108.5
Value as Adjusted to 47-40 Base	131.5	132.0	132.7	132.9	134.0	134.5	134.6	134.7	134.9	135.4	136.2	136.7
% of Base Month's Index Value	117.7	118.1	118.8	119.0	120.0	120.4	120.5	120.6	120.8	121.2	122.0	122.4
1970												
X	205	206	207	208	209	210	211	212	213	214	215	216
Original Index Value	109.3	109.7	109.9	109.9	110.1	110.3	110.9	110.5	111.0	111.0	110.9	111.0
Value as Adjusted to 47-40 Base	137.7	138.2	138.5	138.5	138.7	139.0	139.7	139.2	139.9	139.9	139.7	139.9
% of Base Month's Index Value	123.3	123.8	124.0	124.0	124.2	124.4	125.1	124.7	125.2	125.2	125.1	125.2

Table B.9

Wholesale Price Index All Commodities) as Prepared by the United States Department of Labor, as Adjusted to the 1947-49 Base Period and presented as a Percentage of the Base Month's* Index Value Post-1964 (continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct	Nov.	Dec.
1971												
X	217	218	219	220	221	222	223	224	225	226	227	228
Original Index Value	111.8	112.8	113.0	113.3	113.8	114.3	114.6	114.9	114.5	114.4	114.5	115.4
Value as Adjusted to 47-49 Base	140.9	142.1	142.4	142.8	143.4	144.0	144.4	144.8	144.3	144.2	144.3	145.4
% of Base Month's Index Value	126.1	127.3	127.5	127.8	128.4	128.9	129.3	129.6	129.2	129.1	129.2	130.2
1972												
X	229	230	231	232	233	234	235	236	237	238	239	240
Original Index Value	116.3	117.3	117.4	117.5	118.2	118.8	119.7	119.9	120.2	120.0	120.7	122.9
Value as Adjusted to 47-49 Base	146.6	147.8	147.9	148.1	148.9	149.7	150.8	151.1	151.5	151.2	152.1	154.9
% of Base Month's Index Value	131.2	132.3	132.4	132.6	133.3	134.0	135.0	135.3	135.6	135.4	136.2	138.6

*September 1955

†From December 1964 through December 1972

the slopes of the regression curves are not similar. The conclusion must be accepted that the wholesale price index is inappropriate for this period.

Part III. The tabulated results of the t test applied to the comparison of the slopes of regression lines for wholesale gasoline prices before and after the change in the oil import program follow:

Table B.10

Regression Table for Oklahoma Wholesale Gasoline Prices as a Percentage of the Base Month Price September 1955 to August 1959

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Regression	7,13256	1	7,13256
Residual	4,28932	46	.093246
Totals	11,4219	47	.243019

F = 76.4918

Coefficient of Determination = .624465

Coefficient of Correlation = .790231

Standard Error of Estimate = .305362

When the value of x is 78 then y is 12,706

n_1 = 48

Coefficients

$B_{(0)}$ = 10.5355

$B_{(1)}$ = .0278263

Table B.11

Regression Table for Oklahoma Wholesale Gasoline Prices as a Percentage of the Base Month Price September 1960 to August 1964

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Regression	11.7411	1	11.7411
Residual	14.8019	46	.32178
Total	26.543	47	.5547446

F = 36.4879

Coefficient of Determination = .442342

Coefficient of Correlation = .665088

Standard Error of Estimate = .567257

When the value of x is 93 then y is 13.2642

When the value of x is 140 then y is 11.5862

n_2 = 48

Coefficients:

B(0) = 16.5643

B(1) = 3.57007

$s_{x_1}{}^2$ = 195.99198

$s_{x_2}{}^2$ = 196.00677

s^2_{yxp} = .2075132

s_{yxp} = .455537

t = 9.46102

With 92 degrees of freedom, t is definitely from zero at the 99 percent confidence level, This fact implies that the data are not from the same population even though it is known that the firms in the market place have not changed appreciably and demand has increased over this time interval.

APPENDIX C

IMPACT OF ELECTRIC UTILITIES' DISCRIMINATORY PRICING ON PETROLEUM-REFINERY PRODUCT PRICING

Winter has historically been a slack season for the electric utilities. As a consequence, their marketing personnel have developed a successful promotional campaign designed to induce homeowners to heat with electricity. Coupled with this campaign was a materially reduced cost based upon the marginal cost to the electric company. In addition to the rate reduction during the winter months, those who heat with electricity have also received a reduction in rate throughout the rest of the year. The author assumed that this reduction was justified on the grounds of increased consumption at a single facility, i.e., on the grounds of lower distribution costs. Such an assumption does not seem to hold true for commercial deliveries of electrical power. Although the average commercial user consumes more electrical energy than the average residential consumer, the national average cost per kilowatt-hour is more for the commercial user than for the residential user.

Until a careful study is made of the current situation, these reasons for price discrimination all appear logical applications of sound economic theory. To study the matter further it becomes necessary to examine both sales to ultimate consumers and average revenue by type of consumer. In December, 1972, the average revenue per kilowatt-hour for the three natural divisions of ultimate consumers was as follows:[1]

1. Residential users 1.73¢ per kwh.
2. Commercial users 1.95¢ per kwh.
3. Industrial users .96¢ per kwh.

The reason for the favorable rate to industry is made more clear when considered in the light of the regulations imposed on electric utilities. Since return on investment is carefully controlled by regulatory agencies, there are three ways to increase profit, considering only revenue:

1. Keep high-revenue projects out of the rate base.
2. Maintain low-revenue products in the rate base.
3. Increase the size of the rate base.

The telephone company has been rather successful in the manipulation of methods 1 and 2 above, i.e., setting up subsidiaries and selling "special services" outside the rate base. Subsidiaries of American Telephone and Telegraph control patents on touchtone phones, princess phones and other special options available to subscribers outside the rate base.

The electric utilities have not been successful in this area of discriminatory pricing and as a consequence have looked to an expanding rate base for their increases in profit. This constant attempt to expand the rate base has produced repeated regular blackouts and brownouts in certain areas of the country where total electric-generating

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[1]Federal Power Commission Electric Power Statistics, December, 1972.

facilities have been overtaxed due to oversubscription of customers. In this context the action of the electric utilities in reducing off-season rate, rather than penalizing peak-load users, is logical (to the industry) because it will allow an expansion of the revenue base rather than force a fight for higher returns on an existing base. Figure C.1 and Tables C.1 - C.4 present sales of electrical energy to ultimate consumers during the last seven years of the period under observation by months. For several consecutive years each winter's peak for residential users exceeded the previous summer's high.

To get a clearer picture of what actually causes the extreme summer consumption, Figure C.2 and Tables C.5 - C.6 show total sales, total sales less residential sales, and total sales less commercial sales. This graph clearly demonstrates that it is commercial sales that cause our high summer consumption while the total sales less commercial sales shows that the winter brownouts are due to residential users' demands for heating. The energy crisis as it pertains to the generation of electrical energy is real and has been caused in part by this frantic rush to sign up more subscribers. The current advertising (in effect for the last several years) coupled with the discriminating rate for home-heating purposes has added to the problem.

Logically, advertising for total-electric homes should not be allowed if it is the utilization of the slack season's idle capacity which allows the favorable rate since

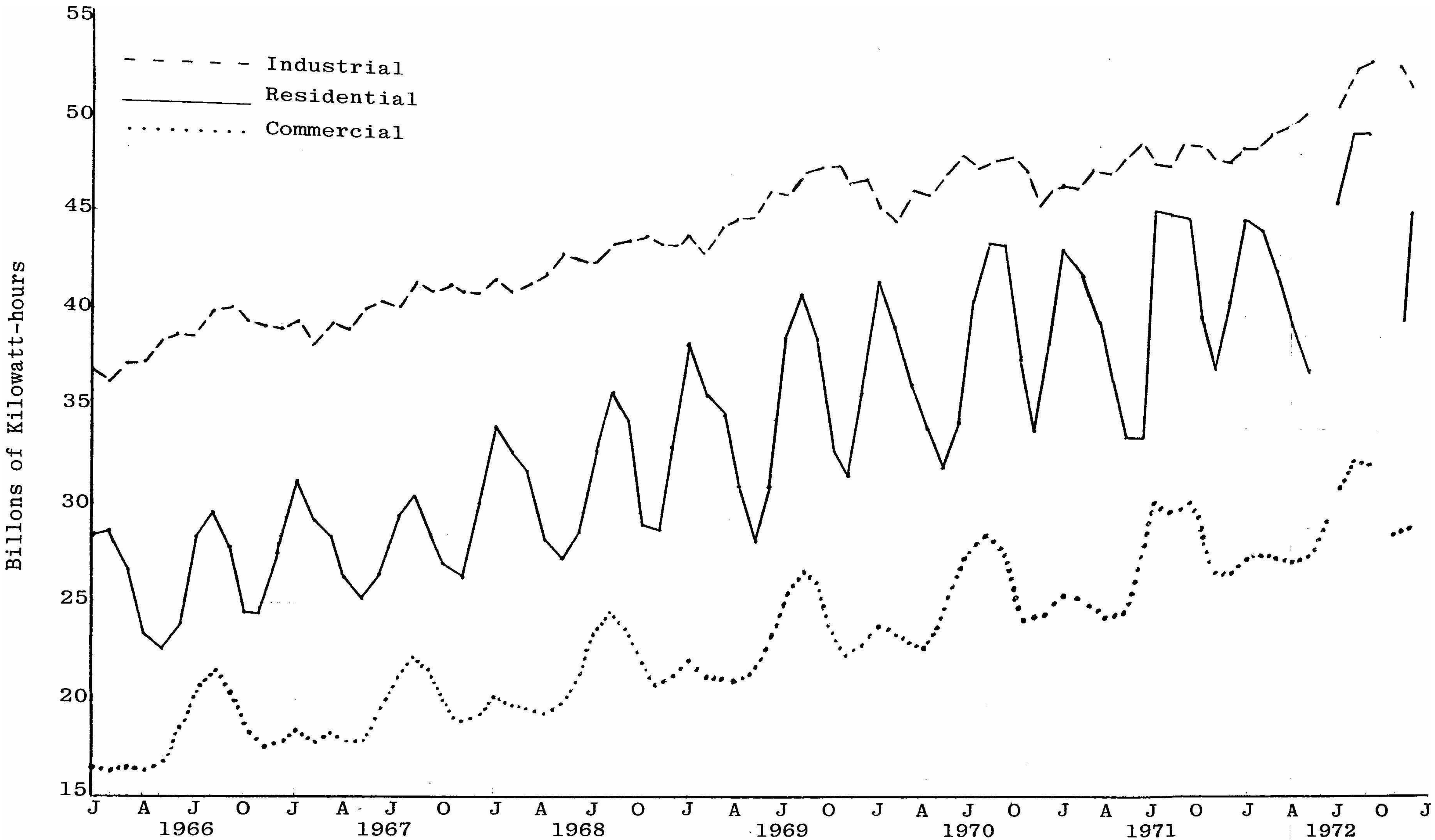

Figure C.1

Residential, Commercial, and Industrial Sales
of Electrical Energy 1966-1972

Source:

Federal Power Commission Electric Power Statistics.

Table C.1

Electrical Consumption of Residential Users
1966 to 1972, in 000's of kwh

Month	1966	1967	1968	1969	1970	1971	1972
January	28,333,064	31,245,157	34,640,452	39,034,709	42,543,533	44,554,043	46,250,689
February	28,481,154	29,326,152	33,024,336	36,281,014	40,035,784	43,166,376	45,592,560
March	26,709,969	28,892,683	32,119,489	35,152,272	37,303.178	40,654,399	43,537,422
April	24,390,597	26,400,500	28,428,208	31,856,319	34,920,695	37,476,533	40,427,733
May	22,979,361	25,363,327	26,690,874	28,916,852	32,896,086	34,671,705	38,057,805
June	24,013,471	26,608,040	29,065,310	31,737,003	35,165,414	34,493,566	....
July	28,300,319	29,845,426	33,242,276	39,653,187	41,993,068	46,999,722	47,762,635
August	29,760,336	30,608,987	36,250,866	41,862,885	44,852,093	46,413,295	51,068,318
September	27,840,214	28,867,483	34,919,271	39,492,681	44,786,776	46,245,415	51,068,318
October	24,690,912	26,287,099	29,481,353	33,367,337	38,610,580	40,972,422	....
November	24,511,883	26,669,604	29,154,495	32,275,506	34,730,517	38,017,401	41,667,137
December	27,602,394	30,217,486	33,443,250	36,629,282	39,160,586	41,950,273	47,049,438

Source:

Federal Power Commission Electric Power Statistics, 1966 to 1972.

Table C.2

Electrical Consumption of Commerical Users
1966 to 1972, in 000,s of kwh

Month	1966	1967	1968	1969	1970	1971	1972
January	16,733,145	18,371,584	20,220,517	22,091,419	24,128,646	25,881,162	27,888,043
February	16,721,017	17,941,450	19,906,518	21,579,076	23,753,326	25,683,107	27,929,036
March	16,736,551	18,187,108	19,828,646	21,394,201	23,419,890	25,276,675	27,846,161
April	16,633,207	17,934,138	19,338,266	21,060,966	23,237,928	24,888,597	27,750,530
May	16,966,155	17,976,926	19,955,537	21,540,677	24,110,730	24,915,553	27,981,038
June	18,648,654	19,777,118	21,675,517	23,781,204	26,125,928	27,561,982	....
July	20,822,197	21,396,778	23,617,598	26,046,352	28,085,755	30,727,002	32,099,712
August	21,266,123	22,246,611	24,879,619	26,928,046	29,051,264	30,422,309	33,516,438
September	20,510,651	21,421,950	23,994,077	26,505,780	28,929,424	30,710,095	33,446,565
October	18,363,100	19,955,001	22,073,617	23,952,703	26,702,944	28,734,949	....
November	17,490,169	18,953,507	20,835,718	22,619,679	24,338,757	27,099,684	29,365,704
December	17,912,834	19,307,562	21,079,286	23,040,283	24,776,338	27,005,474	29,668,956

Source:

Federal Power Commission Electric Power Statistics, 1966 to 1972.

Table C.3

Electrical Consumption of Industrial Users
1966 to 1972 in 000's of kwh

Month	1966	1967	1968	1969	1970	1971	1972
January	36,998,928	39,692,110	42,088,360	44,648,534	46,440,222	47,500,985	50,162,990
February	36,074,581	38,315,613	41,500,540	43,948,452	45,749,257	47,420,641	50,150,584
March	37,421,308	39,633,517	42,014,317	45,103,510	47,313,220	48,844,114	51,474,043
April	37,506,296	39,307,017	42,396,050	45,494,362	47,002,851	48,792,613	51,405,564
May	38,562,280	40,339,437	43,609,996	46,544,901	48,153,436	49,333,816	52,955,700
June	38,933,543	40,862,265	43,336,785	47,319,968	49,226,033	50,201,951	....
July	38,854,799	40,434,934	43,123,673	47,062,212	48,432,928	49,310,460	52,495,100
August	40,130,093	42,024,352	44,175,294	48,223,324	49,077,462	49,261,610	54,610,524
September	40,121,578	41,584,017	44,234,667	48,417,587	49,176,215	50,214,451	55,218,337
October	39,774,275	41,703,720	44,603,808	48,537,852	48,505,796	50,130,185	....
November	39,420,903	41,290,069	44,030,828	47,140,837	46,952,092	49,637,676	54,937,992
December	39,212,577	41,088,638	44,030,680	47,266,028	47,275,000	49,062,172	53,428,350

Source:

Federal Power Commission Electric Power Statistics, 1966 to 1972.

Table C.4

Electrical Consumption of Total Ultimate Users
1966 to 1972, in 000's of kwh

Month	1966	1967	1968	1969	1970	1971	1972
January	85,012,597	92,556,023	100,556,289	109,657,803	117,190,102	122,223,769	128,765,777
February	84,192,415	88,759,465	97,928,371	105,501,135	113,487,517	120,439,052	128,210,323
March	83,861,060	89,969,331	97,402,912	105,457,004	111,930,210	118,956,243	127,366,172
April	81,359,769	86,742,394	93,435,047	102,044,741	109,022,580	115,212,262	123,946,619
May	81,411,260	86,845,565	95,591,462	100,663,436	109,073,700	112,985,153	123,388,545
June	84,489,453	90,397,635	97,445,983	106,551,866	114,474,146	120,446,565	....
July	90,975,986	94,831,711	103,460,504	116,604,550	122,583,939	131,365,887	136,851,456
August	94,192,287	98,179,987	108,929,546	120,927,486	127,133,870	130,423,574	144,504,249
September	91,469,018	95,128,870	106,687,747	118,326,489	127,067,428	131,569,336	144,452,003
October	85,840,748	91,277,083	99,775,574	109,765,641	117,945,906	124,180,032	....
November	84,479,225	90,234,184	97,613,702	105,920,489	110,124,366	119,053,597	130,690,021
December	87,870,368	94,124,259	102,316,190	110,980,206	115,434,029	122,450,264	135,012,831

Source:

Federal Power Commission Electric Power Statistics, 1966 to 1972.

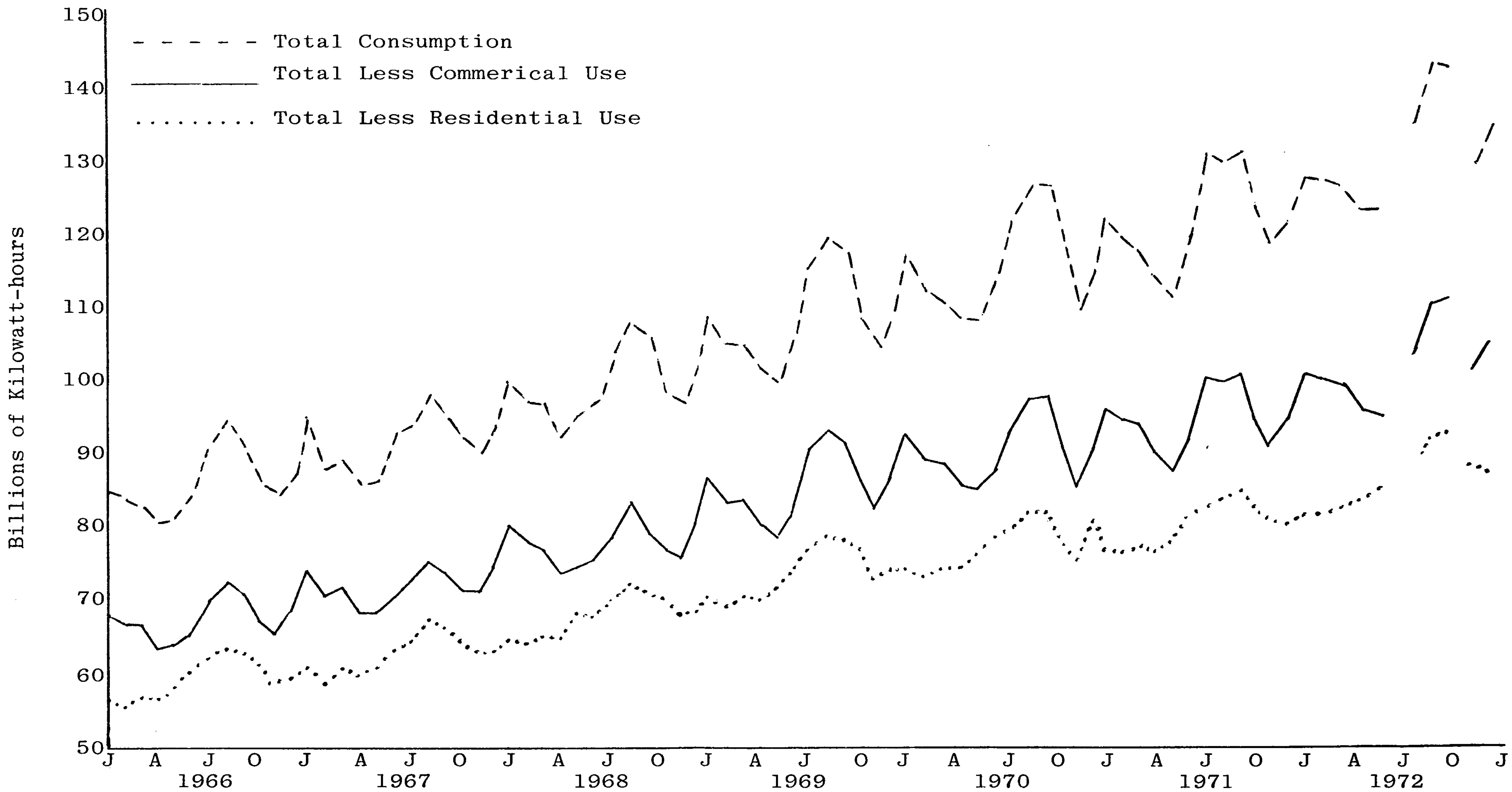

Figure C.2

Selected Combinations of Electrical Consumption
1966 to 1972, in Billions of kwh

Source:

Tables C.1, C.2, and C.4.

Table C.5

Total Electrical Consumption Less Commerical Use
1966 to 1972, in 000's of kwh

Month	1966	1967	1968	1969	1970	1971	1972
January	68,279,452	74,184,439	80,335,772	87,566,284	93,061,366	96,342,607	100,877,734
February	67,471,398	70,818,015	78,021,853	83,922,059	89,734,191	94,755,945	100,281,287
March	67,124,509	71,782,223	77,576,266	84,002,803	88,560,320	93,679,588	99,520,011
April	64,326,562	68,808,256	74,096,781	80,983,775	85,784,642	90,323,665	96,196,089
May	64,445,105	68,868,639	75,635,925	79,122,809	84,962,970	88,069,600	95,407,507
June	65,840,799	70,620,517	75,770,466	82,770,662	88,348,218	92,884,583	....
July	70,153,789	73,434,923	79,842,906	90,558,198	94,498,184	100,638,885	104,751,744
August	72,926,164	75,933,306	84,049,927	93,999,440	98,082,606	100,001,265	110,957,744
September	70,958,367	73,706,920	79,693,670	91,820,709	98,138,004	100,859,241	111,005,438
October	67,477,648	71,322,082	77,701,957	86,812,938	91,239,962	95,445,083	....
November	66,989,056	71,370,677	76,777,984	83,300,810	85,785,616	91,953,913	101,324,317
December	69,957,534	74,816,697	81,236,904	87,939,923	90,657,691	95,444,790	105,343,875

Source:

Federal Power Commission Electric Power Statistics, 1966 to 1972.

Table C.6

Total Electrical Consumption Less Residential Use
1966 to 1972, in 000's of kwh

Month	1966	1967	1968	1969	1970	1971	1972
January	56,679,533	61,310,866	65,915,837	70,622,994	74,646,569	77,669,726	82,515,088
February	55,711,261	59,433,313	64,904,035	69,220,121	73,451,733	77,322,676	82,617,783
March	57,151,091	61,076,948	65,283,423	70,304,732	74,677,032	78,301,844	83,828,750
April	56,969,172	60,341,894	65,006,847	70,188,422	74,101,885	77,735,729	83,518,886
May	58,431,899	61,482,238	68,900,588	71,751,628	76,177,614	78,313,448	85,330,740
June	60,475,982	63,789,595	68,380,673	74,814,863	79,308,732	81,952,999	....
July	62,675,667	64,986,285	70,218,328	76,951,363	80,590,871	91,563,834	89,088,821
August	64,431,951	67,571,000	72,678,680	79,064,601	82,281,777	84,010,276	92,752,006
September	63,628,804	66,261,387	71,768,476	78,833,808	82,280,652	85,323,921	93,383,685
October	61,149,836	64,989,984	70,294,221	76,398,304	79,335,326	83,207,610	....
November	59,967,342	63,654,580	68,459,207	73,644,983	75,393,849	81,036,196	89,022,884
December	60,267,974	63,906,773	68,872,940	74,350,924	81,273,443	80,499,991	87,963,393

Source:

Federal Power Commission Electric Power Statistics, 1966 to 1972.

the subscription of the same customer in the new home to total electric consumption to further increase the summer peak load clearly sets up a self-perpetuating slack period. The illustrations demonstrate that in 1971 and 1972 the residential sales considered alone reversed a previously existing trend to balance the summer and winter peaks which had almost been achieved (compare the summer of 1971 and the winter of 1971).

APPENDIX D

BASIC PHASE IV PRICING FORMULA AND COMPUTATION INSTRUCTION SHEETS

BASIC PHASE IV PRICING FORMULA

$$
D^{u}_{ij} = \frac{
\left[\left(\sum_{k}\left|C^{t}_{k} Q^{t}_{k} - C^{o}_{k} Q^{o}_{k} - \frac{\sum_{k=1}^{2} C^{o}_{k} Q^{o}_{k}}{\sum_{k=1}^{2} Q^{o}_{k}} \left(Q^{t}_{k} - Q^{o}_{k}\right)\right|\right) \times \frac{\left(\sum_{j=1}^{3} p_{ij}\, q_{ij}\right)}{\left(\sum_{i=1}^{4} \sum_{j=1}^{3} p_{ij}\, q_{ij}\right)}
+
\sum_{k}\left[p^{i}_{ik}\, q^{t}_{ik} - p^{o}_{ik}\, q^{o}_{ik} - \left\{\left(\frac{\sum_{j=1}^{3} p^{o}_{ij}\, q^{o}_{ij}}{\sum_{j=1}^{3} q^{o}_{ij}}\right) - \left(\frac{\sum_{j=1}^{2}\left[p^{o}_{ij}\, q^{o}_{ij} \left(p^{o}_{ij} - p^{o}_{i3}\right)\right]}{\sum_{j=1}^{2} p^{o}_{ij}\, q^{o}_{ij}}\right)\right\} \times \left\{q^{t}_{ik} - q^{o}_{ik}\right\}\right] \times \frac{p_{ij}\, q_{ij}}{\sum_{j=1}^{3} p_{ij}\, q_{ij}}\right]
}{q^{u}_{ij}}
$$

Figure D.1

Table D.1

COMPUTATION INSTRUCTION SHEET – APPLICATION OF FORMULA PER § 150.356

(A) LINE NO	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) DOMESTIC K=1	(F) IMPORTED K=2	(G) TOTAL
1	C_k^t	CRUDE PURCHASES COST/BBL – PD OF MEASUREMENT				
2	C_k^o	COST/BBL – BASE PERIOD				
3	Q_k^t	BBLS – PERIOD OF MEASUREMENT				
4	Q_k^o	BBLS – BASE PERIOD				
5	$C_k^t\ Q_k^t$	IN $ – PERIOD OF MEASUREMENT	1 X 3			
6	$C_k^o Q_k^o$	IN $ – BASE PERIOD	2 X 4			
		INCREASE (DECREASE)				
7	$C_k^t\ Q_k^t$ — $C_k^o\ Q_k^o$	IN $ PURCHASES	5 – 6			
8	$Q_k^t - Q_k^o$	IN BBLS PURCHASED	3 – 4			
9	X^o	AVERAGE COST/ BBL BASE PERIOD	6 ÷ 4			
10	$X^o\,(Q_k^t - Q_k^o)$	VOLUME ADJUSTMENT BASE PERIOD	9 X 8			
11	A	NET CRUDE COST PASS THROUGH	7 – 10			
12	S^n	TOTAL $ SALES PRIOR YR QTR.				

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
13	s_i^n	$ SALES BY PRODUCT CLASS					
14	s_i^n / s^n	PRODUCT CLASS ALLOCATORS	13 ÷ 12				
15	$A \, s_i^n / s^n$	ALLOCATED CRUDE PASS THROUGH	11 X 14				
		DOMESTIC PURCHASES					
16	p_{i1}^t	COST/UNIT PERIOD OF MEASUREMENT					
17	q_{i1}^t	UNIT PERIOD OF MEASUREMENT					
18	$p_{i1}^t \; q_{i1}^t$	$ PERIOD OF MEASUREMENT	16 X 17				
19	p_{i1}^o	COST/UNIT BASE PERIOD					
20	q_{i1}^o	UNIT BASE PERIOD					
21	$p_{i1}^o \; q_{i1}^o$	$ BASE PERIOD	19 X 20				

Table D.1 (continued)

(A) LINE NO	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		IMPORTED PURCHASES					
22	p^t_{i2}	COST/UNIT PERIOD OF MEASUREMENT					
23	q^t_{i2}	UNITS PERIOD OF MEASUREMENT					
24	$p^t_{i2}\ q^t_{i2}$	S PERIOD OF MEASUREMENT	22 X 23				
25	p^o_{i2}	COST/UNIT BASE PERIOD					
26	q^o_{i2}	UNITS BASE PERIOD					
27	$p^o_{i2}\ q^o_{i2}$	S BASE PERIOD	25 X 26				
		INCREASE (DECREASE)					
28	$p^t_{i1}\ q^t_{i1} - p^o_{i1}\ q^o_{i1}$	IN S PURCHASED DOMESTIC	18 – 21				
29	$p^t_{i2}\ q^t_{i2} - p^o_{i2}\ q^o_{i2}$	IN S PURCHASED IMPORTED	24 – 27				
30	$p^t_i\ q^t_i - p^o_i\ q^o_i$	IN S PURCHASED TOTAL	28 + 29				
31	$q^t_{i1} - q^o_{i1}$	IN QTY PURCHASED DOMESTIC	17 – 20				
32	$q^t_{i2} - q^o_{i2}$	IN QTY PURCHASED IMPORTED	23 – 26				
33	$q^t_i - q^o_i$	IN QTY PURCHASED TOTAL	31 + 32				

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		BASE PD. PROD. SALES:					
34	p^o_{ij} j = 1	PRICE/UNIT–CONSUMERS					
35	q^o_{ij} j = 1	UNITS SOLD-CONSUMERS					
36	$p^o_{ij} q^o_{ij}$ j = 1	$ SOLD – CONSUMERS	34 X 35				
37	p^o_{ij} j = 2	PRICE/UNIT – RETAILERS					
38	q^o_{ij} j = 2	UNITS SOLD–RETAILERS					
39	$p^o_{ij} q^o_{ij}$ j = 2	$ SOLD–RETAILERS	37 X 38				
40	p^o_{ij} j = 3	PRICE/UNIT–WHOLESALERS					
41	q^o_{ij} j = 3	UNIT SOLD–WHOLESALERS					
42	$p^o_{ij} q^o_{ij}$ j = 3	$ SOLD–WHOLESALERS	40 X 41				
43	$\sum_{j}^{3}(p^o_{ij} q^o_{ij})$	TOTAL $ SALES	36 + 39 + 42				
44	$\sum_{j}^{3}(q^o_{ij})$	TOTAL UNITS SOLD	35 + 38 + 41				
45	$\sum_{j}^{3}\frac{(p^o_{ij} q^o_{ij})}{(q^o_{ij})}$	WEIGHTED AVERAGE SELLING PRICE	43 ÷ 44				

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		PRICE DIFFERENTAILS	($\triangle$):				
46	$p^o_{ij} - p^o_{i3}$	$\triangle$ CONSUMERS: WHOLESALERS	34 – 40				
47	$p^o_{i1} q^o_{i1} (p^o_{ij} - p^o_{i3})$	WEIGHTED $\triangle$	36 X 46				
48	$p^o_{i2} - p^o_{i3}$	$\triangle$ RETAILERS: WHOLESALERS	37 – 40				
49	$p^o_{i2} q^o_{i2} (p^o_{i2} - p^o_{i3})$	WEIGHTED $\triangle$	39 X 48				
50	$\sum_j^2 (p^o_{ij} q^o_{ij} (p^o_{ij} - p^o_{i3}))$	TOTAL WEIGHTED $\triangle$	47 + 49				
51	$\sum_j^2 (p^o_{ij} q^o_{ij})$	TOTAL SALES– CONSUMER + RETAIL	36 + 39				
52		WEIGHTED RETAIL PRICE ADJUSTMENT	50 ÷ 51				
53	Y^o	NET WHOLESALE PRICE ADJUSTMENT FACTOR	45 – 52				
54	$Y^o(q^1_{i1} - q^o_{i1})$	WHOLESALE PRICE ADJUSTMENT — DOMESTIC	53 X 31				
55	$Y^o(q^1_{i2} - q^o_{i2})$	WHOLESALE PRICE ADJUSTMENT IMPORTED	53 X 32				
56		COST PASS THRU DOMESTIC	28 – 54				

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPU-TATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
57		COST PASS THRU IMPORTED	29 – 55				
58	B	TOTAL PURCHASED PRODUCT PASS THRU	56 + 57				
59	$A \cdot S^n_i / S^n$	ALLOCATED CRUDE PASS THRU	15				
60	$(A \cdot \frac{S^n_i}{S^n} + B) \equiv C$	TOTAL COST PASS THRU	58 + 59				
		$ SALES TYPE OF PRODUCT W/I LEVEL OF DISTRIBUTION					
61	$S^n_{ij} \quad j = 1$	CONSUMERS					
62	$S^n_{ij} \quad j = 2$	RETAILERS					
63	$S^n_{ij} \quad j = 3$	WHOLESALERS					
		PRODUCT TYPE W/I LEVELS OF DISTRIBUTION ALLOCATION %'s					
64	$S^n_{ij} / S^n_i \equiv f_{i1}$	CONSUMERS	61 ÷ 13				
65	$S^n_{i2} \quad S^n_i \equiv f_{i2}$	RETAILERS	62 ÷ 13				
66	$S^n_{i3} \quad S^n_i \equiv f_{i3}$	WHOLESALERS	63 ÷ 13				
67	$S^u_4 / S^u \equiv f_4$	% DISTRIBUTION TO OTHER THAN SPECIAL PRODUCTS	COL H LINE 14				

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		CURRENT ALLOWABLE COST PASS THROUGHS PRODUCTS W/L LEVEL OF DISTRIBUTION					
68	$C \cdot f_{i1} \equiv D^{*}_{i1}$	SPECIAL PRODUCTS CONSUMERS	60 X 64				
69	$C \cdot f_{i2} \equiv D^{*}_{i2}$	RETAILERS	60 X 65				
70	$C \cdot f_{i3} \equiv D^{*}_{i3}$	WHOLESALERS	60 X 66				
71	$C \cdot f_{i4} \equiv D^{*}_{4}$	OTHER THAN SPECIAL PRODUCTS	60 X 67				
		AVAILABLE $ COST PASS THROUGH FROM PREVIOUS MONTH	PREVIOUS MONTH				
72	$D^{\dagger}_{i1}$	SPECIAL PRODUCTS CONSUMERS	LINE 88				
73	$D^{\dagger}_{i2}$	RETAILERS	LINE 89				
74	$D^{\dagger}_{i3}$	WHOLESALERS	LINE 90				
75	$D^{\dagger}_{4}$	OTHER THAN SPECIAL PRODUCTS	LINE 91				

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		ACTUAL COST PASS THROUGH TAKEN PREVIOUS MONTH					
		SPECIAL PRODUCTS					
76	$\hat{D}^{t}_{i1}$	CONSUMERS					
77	$\hat{D}^{t}_{i2}$	RETAILERS					
78	$\hat{D}^{t}_{i3}$	WHOLESALERS					
79	$\hat{D}^{t}_{4}$	OTHER THAN SPECIAL PRODUCTS					
		MAXIMIM CURRENT ALLOWABLE PASS THROUGH					
		SPECIAL PRODUCTS					
80	D'_{i1}	CONSUMERS	80 = 68 + 72 − 76				
81	D'_{i2}	RETAILERS	81 = 69 + 73 − 77				
82	D'_{i3}	WHOLESALERS	82 = 70 + 74 − 78				
83	D'_{4}	OTHER THAN SPECIAL PRODUCTS	83 = 71 + 75 −79				

Table D.1 (continued)

(A) LINE NO	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPUTATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		CURRENT AMOUNT ASSIGNED TO OTHER PRODUCTS					
84	$H^{\dagger}_{i1}$	SPECIAL PRODUCTS CONSUMERS	84 ≤ 80				
85	$H^{\dagger}_{i2}$	RETAILERS	85 ≤ 81				
86	$H^{\dagger}_{i3}$	WHOLESALERS	86 ≤ 82				
87	$H^{\dagger}_{4}$	CURRENT TOTAL AMT. ASSIGNED TO OTHER PRODUCTS	87 ≤ 83				
		CURRENT ALLOWABLE COST PASS THROUGH					
88	D^{u}_{i1}	SPECIAL PRODUCERS CONSUMERS	80 – 84				
89	D^{u}_{i2}	RETAILERS	81 – 85				
90	D^{u}_{i3}	WHOLESALERS	82 – 86				
91	D^{u}_{4}	OTHER THAN SPECIAL PRODUCTS	83 + 87				
		ESTIMATED UNIT SALES–CURRENT MONTH					
92	q^{u}_{i1}	SPECIAL PRODUCTS CONSUMERS					
93	q^{u}_{i2}	RETAILERS					
94	q^{u}_{i3}	WHOLESALERS					

Table D.1 (continued)

(A) LINE NO.	(B) MATH NOTATION PER § 150.356	(C) DESCRIPTION	(D) COMPU-TATION LINE NO.	(E) i = 1 No. 2 HEATING OIL	(F) i = 2 GASOLINE	(G) i = 3 No. 2 D DIESEL FUEL	(H) i = 4 OTHER
		MAXIMUM CURRENT ALLOWABLE UNIT PRICE INCREASE					
95	d^u_{i1}	SPECIAL PRODUCTS CONSUMER	80 ÷ 92				
96	d^u_{i2}	RETAILERS	81 ÷ 93				
97	d^u_{i3}	WHOLESALERS	82 ÷ 94				
		ACTUAL UNIT PRICE INCREASES					
98	$\hat{d}^u_{i1}$	SPECIAL PRODUCTS CONSUMERS	47 ≤ 95				
99	$\hat{d}^u_{i2}$	RETAILERS	48 ≤ 96				
100	$\hat{d}^u_{i3}$	WHOLESALERS	49 ≤ 97				

APPENDIX E

INTERVIEW RESULTS

The results of interviews reported were purposely divided into three size groupings. The groupings do not conform to any normal division of size but were selected for the primary purpose of revealing an indication of size while concealing specific identity. The groupings will be reported as follows:

1. A large company - 200,000 barrels per day.
2. An intermediate company - between 30,000 and 200,000 barrels per day.
3. A small company - less than 30,000 barrels per day.

Company Z

The interview with Company Z, a larger company, was conducted with the manager of planning and economics.

Refinery investment decisions were under consideration by Company Z at various intervals throughout the period 1963 to 1973. Return on investment for totally new construction was considered submarginal. Primary expansion during the period was limited to existing facilities. Capacity was added in bottlenecked areas by rounding out capacity to the maximum output of existing, previously overbuilt, operations. This approach has produced an acceptable but not extremely gratifying return on investment. A more progressive approach was abandoned because the return forecast did not meet minimum acceptable requirements.

A representative of Company Z answered all questions but was very reluctant to volunteer any additional information on his own company. He did not have the same reluctance in commenting about other companies' operations and labeled one of the other firms contacted by this writer as a maverick. The reason expansion was possible for existing refineries was stated to be overcapacity of catalysts when they were first introduced in refineries. When considering the construction of totally new refineries this firm normally planned to close small, older, existing facilities and to contract a portion of the new refineries temporary excess production to other firms. Any plans for totally new construction are subject to availability of crude oil and therefore are not current. During the period under study Company Z reported investment costs on specific proposed projects which were more than 50 percent higher than when projects were first considered.

The interview disclosed a very strong need for greater flexibility in accounting to allow this company to conform more rapidly to the requirements of government regulations, specifically Phase IV controls. There was no opportunity to examine the results of postaudit evaluations of this firm. In fact, there was a specific firm statement to the contrary in the invitation to conduct the interview. This firm favored a relative-value cost allocator under Phase IV.

Company Y

The interview with Company Y, a small company, was conducted with the president. Company Y had been content to remain about the same size for most of the period considered. It is the subsidiary of another small company as far as refinery capacity is concerned. However, the parent has production facilities which assist both itself and the subsidiary of an intermediate-size refinery for a portion of its product distribution. The firm is somewhat unusual in its operation but those unusual features can not be mentioned without revealing identity.

The firm made several expansions in recent years and has realized a good return on its investments. The expansions were not construction of totally new facilities, but additions to existing plants, sometimes utilizing used equipment. Payout has been as brief as three years on pipeline investment and the company is assured a relatively steady availability of crude oil from that source. The firm has remained small even after expanding its processing of crude several times. The president was most cooperative and provided additional published information concerning general conditions in the industry. There was a review of specific investment proposals but only to the extent that brief notes were taken.

Company X

The interview with Company X, a small company, was conducted with two different individuals. Company X had been acquired by another firm shortly prior to the interview. The initial contact was with the vice-president of marketing who explained the current operating characteristics of the new firm. The intense problems of the acquisition prevented a discussion with the current president, but the former president of Company X was located and was most cooperative in advising concerning operations of that company during the period under consideration. Company X was under severe competition in a limited geographical area with declining crude-oil availability and had to ship crude oil in by tank car. This firm was the subsidiary of another firm for most of the period under consideration. It had relatively heavy production of asphalt and suffered when in the words of its former president, "a competitor broke the asphalt price in 1968."

Company X's operation was a declining operation in a dying field. The new firm was rapidly expanding by acquiring small producing and refining companies in a rather intense pattern, having acquired at least five in less than two years. The strengths of some subsidiaries would offset the weaknesses of others and produced a rather sound structure. Had Company X not been acquired it probably would have ceased to exist.

Company W

No interview was conducted with Company W, a small company. The specific reason given by the president was:

> The title of your dissertation does sound interesting, and we appreciate your thinking of us to work with you in preparing your needed information. Due to the tremendous amount of paper work that is being generated through the various governmental control programs it would not be possible for us to devote the time to contribute to your efforts, and it would be wise for us to decline at this time.[1]

Company V

The interview with Company V, an intermediate-size company, was conducted with the vice-president of planning. The firm experienced two refinery expansions during the period of this study and obtained a minimal return on investment for both. Reasons other than return on investment prompted management to expand. In one instance the expansion involved a pipeline decision and in another instance the expansion involved upgrading to meet the new emissions requirements. The firm has a growing market for its product, a definite crude-oil deficiency, and follows a basic independent pricing approach to marketing. In a few areas the company marketed at major oil-company prices but in most areas it acted as an independent, pricing one or two cents below the major, with a firm policy of meeting the lowest price in the area.

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[1]Name withheld by request.

Although the normal tendency was for intermediate firms to experience modest returns on investment, this firm's minimal return is probably related to the type of expansion. Upgrading of the product usually requires new equipment but most firms of this size would normally consider used equipment for their other expansions.

Company U

The interview with Company U, a large company, was arranged by the public affairs department and conducted with a member of the controller's staff who was in charge of a special group monitoring Phase IV operations. The firm's representative had previous experience in refinery management and also in the corporate planning department.

In addition, there was also a discussion with the head of the economics department relative to the views expressed in Chapter 3. Company U was extremely cooperative. After disclosing requested information, the company permitted perusal of the correspondence files between its firm and the cost-of-living council and also Mr. Simon's energy group. The firm followed the general pattern for large companies and disclosed minimal returns on investment on totally new refinery facilities. The return on investment was better for expansion of existing facilities and the company indicated that reasons other than return on investment were primarily responsible for the final refinery-investment decisions. The merger of two large companies (for which no antitrust action was initiated) forced a shutdown of one of this firm's refineries.

The qualifications of the firm's representatives prompted some questions involving his personal opinion regarding economies of scale and a comparison of a large firm with a small firm. He listed the following advantages for a small firm:

1. An independent can move faster.
2. Can give better service.
3. Can tailor size to specific location and circumstances.
4. Has transportation economies.
5. Can build to merely meet state codes.
6. Is not troubled with hardening of the arteries (rigid policies restricting freedom of movement) and may consider unique solutions to short-run problems.
7. Government favoritism existed.
8. The company can be an individualist.
9. The small firm will not encounter severe competitive pressures unless it is engaged in overgrowth (expands to some other firm's envisioned market).

In response to a direct question this representative stated that if he wished to he could start and successfully operate a small refinery in competition with the major company that is his present employer.

A study was prepared by this firm which compared the domestic integration balance with cumulative dealer tank-wagon increases in cents per gallon. The results of this study provide data showing the extreme difference in competitive prices available to firms with very high domestic production and those with extremely low domestic production, particularly old production which is severely limited in crude-oil price compared to new produced oil and imported oil.

This firm did not engage in any product dumping during the period under observation and seemed to be rather unique in that regard. A specific cost method used for internal product-mix evaluation assigned a cost differential to the components of the product mix based on the latest cost to upgrade products by the latest techniques available. Company U favored a volume-oriented cost allocation under Phase IV controls and appeared to be instrumental in assisting in the adoption of this policy by the government.

Although cooperating fully with the questions asked and volunteering additional information of both a current and a historical development nature, the company did not allow a direct postaudit evaluation.

Company T

The interview with Company T, a large company, was conducted with the former head of forward planning (the operating head of forward planning at the time the decisions discussed were made) and a current member of the planning department. Brief contact was also made with the current vice-president in charge of forward planning.

Company T has established a pattern of marketing expansion which deliberately caused sales to exceed refinery capacity until a critical point was reached. At this time a refinery would be constructed which would somewhat exceed this company's total market demand so that for a short time excess refinery capacity would exist for the firm. The company found itself needing expansion in refinery capacity in the late 1960's and began a study which resulted in a refinery-investment decision. The study of return on investment was conducted merely as a precaution against a losing operation since the decision was largely based upon the firm's market demand. Was it more economical to buy product with which to meet this demand or to manufacture it?

The price of products during this period was depressed and the resultant financial analysis indicated that the refinery-investment decision would generate no large return on investment but rather would barely exceed the minimum requirement. The firm concluded that the alternative, purchasing their products from outsiders, was potentially the more expensive approach with even less potential return. An overriding consideration which seemed to be the deciding factor was the cost of construction itself. Company management decided that the time had come to construct a refinery because other companies were not constructing and favorable construction contracts were available.

Throughout the interview company representatives emphasized the important role of competition for both price and product-mix determination. They could not refute the argument that government regulatory agencies had exerted considerable influence in the price area, but they were reluctant to emphasize this approach.

The company is using the equivalent of incremental costing techniques to determine refinery product mixes and production runs. Manufacturing or processing costs are fairly well established on different products, but no attempt is made to allocate the cost of raw material input by product for decision purposes. The company has been analyzing marketing costs in a similar fashion with the intention of "backing up realized prices to the refinery gate."

Company T is just beginning to use Monte Carlo techniques for probability determination and is adopting extensive use of discounted cash flow. The firm has been developing incremental cost techniques assisted by the computer and appears to have manufacturing costs isolated with practical accuracy. Forward-planning personnel have little regard for any attempt to allocate the cost of crude oil among the various products and are reluctant to concede its desirability under any circumstance. Company personnel indicated the decision to build the refinery was indeed fortunate since present circumstances caused the project to exceed all expectations. Prices had recovered and the excess capacity planned prior to construction was immediately utilized upon completion of the refinery. This accelerated utilization of planned expansion capacity caused all projections at the time of the decisions to be surpassed by considerable margins. For these reasons and also due to a lack of operating performance time, management decided against an outsider conducting a postaudit evaluation. The cooperation of Company T greatly exceeded expections in two areas:

1. The decision reviewed was extremely current.
2. The company made available the person actually involved in the original decision, and he was quite open and candid in his comments.

Company S

This intermediate-size company, Company S, was represented in the interview by its president. At the time of the interview the firm's refining capacity exceeded daily production by 10,000 barrels and was only slightly over half of the firm's market for products. The firm acquired two refineries at relatively close intervals. One acquisition was in substance a financial transaction; however, it became unexpectedly profitable to operate both refineries for a while. Later, the refinery investment was developed at one location and the other location was abandoned.

The president of this firm was quite cooperative and spent much time on background information. In the 1930's the Interstate Oil Compact established allowable production for many producing states. The allowables were at a high of 100 percent during World War II and ranged down to as low as 20 percent at one time. These allowables provided a strong inducement for United States companies to go to foreign countries for exploration. The allowables were primarily a price-protecting device which kept marginal producing wells in existence.

The president discussed Truman's standby reserve capacity requested following the Korean conflict, the impact of the Suez Canal blockage, and the threat of cheap foreign oil which ushered in the import program. The oil-import program was first introduced as a voluntary measure. However, several firms immediately took steps to defeat its intent. Commonwealth and Phillips were successful in installing refineries in Puerto Rico with almost 100 percent imported crude oil. Hess succeeded in the Virgin Islands with a similar program and it was not until an attempt was made to install a refinery in Maine utilizing imports exclusively that the pattern was broken. Occidental's efforts to thwart the oil import program were defeated. Following this defeat, the import program became mandatory in 1959. This import program with its import quotas kept marginal refineries in existence as explained in Chapter 3. Firms were mentioned that existed solely on the value of the import tickets.

Additional insights into marketing problems were revealed to be due to loosely worded long-term contracts, originally negotiated between friendly firms. Personnel changes and time caused one firm to seek to take advantage of the poorly worded contract. These contracts took the form of guaranteed margin and provided an advantage to the purchaser whenever the prices were depressed, since the seller bore all the loss.

This firm provided some very factual information concerning the increase in both the size and cost of a totally new refinery. Each of the following proposals was considered and rejected due to inadequate return on investment coupled with high investment costs:

	Year	Size in barrels per day	Cost in million dollars
1.	66-67	90,000	80 to 90
2.	69-70	100,000	100 plus
3.	71	130,000	175 plus
4.	72	150,000 to 200,000	400

Company S was one of the few intermediate-size firms considering totally new refinery investments. Management could not be convinced on the financial data. The firm even considered partnership with a major oil company but without success.

In addition to the information presented, this firm's representative reviewed the basic material in Chapters 2 and 3, making appropriate comments but not refuting the logic. This firm later acquired Company K.

Company R

A large firm, Company R was represented in the interview by its planning coordinator. The firm decided to expand capacity 35,000 barrels per day by retiring some units and making a major addition to an existing refinery. This company followed a regular pattern of expansion at a rapid pace, buying product to fulfill growing demand and building refineries only when there was assured demand for company product. During the late 1960's while normal market expansion for most companies was between 7 and 7½ percent, this firm experienced almost a 9 percent growth rate in gasoline market demand. At the time of the investment decision, refinery capacity was clearly behind market expansion; yet, the acquisition of market share was so favorable that the marketing department received approval for additional expansion. The study took a discounted cash-flow projection form and the return on investment, stated in the interview but not reported here for obvious reasons, was very disappointing to the firm's management. Historically the company did not allow capacity to exceed sales. Even after this decision, refinery capacity was 15,000 barrels per day less than sales and production was considerably less than that.

Other firms were not constructing refineries during this period. Company R was forced into a decision by a deadline for deciding its participation in a pipeline project. Dwindling productive capacity in the area coupled with a fear of insufficient crude supplies at a later date propelled the firm into an early study. The firm thus took positive action while ecological problems were causing others to defer action. The off-cycle timing for refinery expansion created a considerable saving in refinery construction costs.

This firm was interviewed twice. When the first contact was made the large expansion appeared to be a mistake due to the tremendous downward pressure on product prices. However, patience proved the investment decision to be wise. The planning coordinator, somewhat reluctant to disclose internal errors to outside personnel, changed his thought and cooperated fully when the decision proved to be favorable (as his initial study had indicated it should). In this particular instance the planning coordinator had reviewed (in the form of a postaudit evaluation) the original investment decision for management at the time of the first contact. He took the time to reacquaint himself with the decision and the evaluation and discussed both quite freely, even mentioning in confidence figures that were not for publication. More than a year elasped between the first and the second visits to this firm.

Company Q

Company Q was represented by both the vice-president of planning and a member of his department. It is a fully integrated oil company with two major refineries. The accounting department of this intermediate-size company has gone through several accounting methods, including an adjusted Group Three price less discount, a commission-base operation, and a transfer price system. Currently, all refinery operations are handled as one profit center with no attempt to define profit for any segment. The company uses a standard cost system with variance analysis. The firm is basically a cut-rate marketer of petroleum products.

At one point in the existence of Company Q the firm tried to move up to a major marketing style. Discriminatory prices were inadvertently attempted with no discrimination in product name. Large, modern, multibay stations were built in areas where the company's discount stations were still located. The new stations had major pricing and the old stations discount pricing. As might be expected, the customers viewed the new stations as peddlers of cut-rate gasoline at high prices. The company returned to cut-rate marketing policy exclusively. This firm has a flexible pricing policy, evaluating each situation and establishing price based on appearance. Poor stations with poor appearance could cut price by two cents without causing concern but one that appeared competitive would be allowed no price differential. This company did not favor either import quotas or the entire import program.

A specific refinery-investment decision was examined and was reported in Chapter 5 on page 140. The firm is a net purchaser of crude oil and experienced extreme difficulty in obtaining crude-oil requirements. The pressure of current shortages forces a closing of many stations including most of the new stations recently built. The firm is in a fairly competitive position after these closings. The planning department emphasized its opposition to any breakdown of costs in its product mix.

Company P

Company P, a small company, was represented in the interview by both the refining manager and vice president of marketing. There were no expansion plans considered during the period under study. The stated objectives of this refinery was "to survive," and the pricing policy was "the price required to move the product."

Other sources, outside this firm, add somewhat to the picture of Company P's operations. Originally held by a major oil company, this refinery was sold to a firm outside the industry. The increase in import allowables resulting from the refinery size reduction (see Table 4.7, page 123) facilitated payout and improved the economics of this acquisition. The operation of the refinery was controlled by the same manager, i.e., he was acquired from the major with the refinery.

Company O

The views of Company O, a large company, were presented during the interview by a director of operations analysis in the planning division. Repeated studies convinced the planning personnel that the return on investment from totally new refinery construction did not come close to meeting their lowest acceptable return on investment. The appropriate expansion pattern therefore appeared to be expansion of existing facilities and acquisition of any major facilities that could be purchased.

The firm carefully pursued this course of action and represents an exception to the rule for large firms. All large firms have indicated poor returns on investment from totally new refinery facilities. However, Company O has not constructed totally new refineries for any reason, including nonfinancial.

The Company O representative explained several pricing schemes which appeared to be generally used by the industry. These included the crude-replacement-value method and particularly the incremental barrel which he maintained has been sold over the last ten years. A detailed discussion of the inherent flaw in this approach is presented in Chapter 3, beginning on page 63.

The basic conflict between the engineering and the accounting viewpoints on cost allocation first appeared during this interview. An inadequacy in reporting for planning purposes was resolved by methods not involving the accounting department. The firm is currently using computer output for cost allocation and makes only the final year-end adjustment with a price-relative cost allocator. Hostility existed at one time between the accounting and planning departments and there is evidence that this relationship has not fully returned to a spirit of cooperative mutual assistance.

In addition to the director of operations analysis, brief discussions were held with the manager of the planning division and the vice president of refining.

Company N

The interview with Company N, a small company, was conducted with its president. Two expansions were completed during the period under study. Specific discussions centered on the second expansion. The president indicated that the depressed prices for petroleum products hit such a low that refinery construction had to end before the project was fully completed. The refinery was completed to a stage which allowed it to go on stream but many of the auxiliary facilities planned had to be postponed.

The return on investment during this period was characterized as "bad." Additional facts are required to fully understand the implications of this response. Company N has constructed its entire refinery from used equipment. Most of this equipment was purchased at very favorable prices but is in excellent condition. Some was acquired for as little as 10 percent of new-equipment cost. The firm is not content with its present size and has expansions planned for the future. During the depressed price periods this firm made less than the value of the import allowables to which it was entitled; without the allowables it would have lost money.

Although the firm is very conscious of ecological problems and has instituted many improvements in its refinery operation, there was no intention of constructing facilities to meet no-lead-gasoline-production capability. The president indicated a loss of approximately one dollar a barrel before administrative costs on a rather substantial volume of residual fuel. He also stated that any time government decision makers sit down and control the market there is going to be trouble. To support his statement he referred to a cargo of diesel fuel in a market close to his refinery which sold for sixty-two cents a gallon before tax. At the same time the same product at this terminal was about half that price. Quite simply, if his product could have been transported to the market mentioned and sold at the price of the other shipment, a twenty-five-cent-per-gallon profit would have resulted. He further stated that similar things have happened to gasoline prices.

Company M

Company M, of intermediate size, was the first firm contacted and as such represented a pilot project. The senior representative of the economics department provided the basic contact. Company M had engaged in an unusual study of cost over normal operating ranges using the incremental approach. Computer output revealed a similarity of costs for each of three products in the distillate range. Although operating personnel seemed pleased with this study and management implemented changes based on it, reservations are held concerning its validity.

The initial product mix of a refinery is determined only after a series of multiple comparisons involving types of crude oils available, product demands in the geographical area, and the effect of competitive forces upon the firm's products. These interacting forces are so complex that computer models and professional consultants are often needed to arrive at some semblance of an optimum mix. The particular study in question proposed the introduction of an additional volume of crude oil to be made entirely into each of three separate products in the distillate range under three hypothetical cases, each case dealing with a separate product. To accomplish this it was necessary to modify the normal refinery output slightly for each barrel of crude input, moving away from a previously determined optimum mix to an inefficient position. The amount of this change was controlled by flexibility available.

The distillates involved seemed to affect the same blending stocks. Although the writer was not familiar with the stocks involved, they had the same variable names on the computer run. Therefore under normal circumstances each computer output was determining the result of a move away from optimum under which all competitive forces and available supplies had been considered and was instead substituting the consideration of the result of only one product change. Under normal conditions such a move would not be advantageous. A request to look at the price side of this study was denied. Repeated assurances were given that company personnel had examined these prices and that they were not depressed by the additional output. These sustained prices despite increased output could only mean that the firm had either discovered a hole in the market or a flaw in its original estimation of product demand.

The logical result of a discovery that costs were constant throughout an operating range was a move to the highest-revenue product since the products had different revenue potential. Accordingly, a major plant modification was made which maximized the output of that product. A postaudit evaluation of this management decision was prepared and indicated a good return on the investment. This printed evaluation and the computer runs evaluating cost were made available to the author during the interview.

Company L

Company L was a small company and declined the interview for the following reasons:

> I regret to advise that the only project we have that would require new investment has been deferred due to the fact that cost factors in our business are practically changing daily and in fact fluctuating to such an extent that there is no way to develop economic studies at this time.[1]

This firm doubled capacity during later years of the period under study.

Company K

Numerous attempts were made to interview the president of company K, an intermediate-size firm, until it was learned that the reason he was so occupied was that

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[1]Name withheld by request.

company K was being acquired by company S. Since the management of company S's opinions had already been obtained, neither company was approached further.

Company J

Company J was one of the first large companies to be contacted by correspondence. An indirect route through local management was attempted and this approach proved to be poor. The firm declined for the following reason:

> As I am sure you will understand, ... receives a great number of requests both from governmental and nongovernmental sources. The burden of responding to these becomes such that in the interests of stockholders and from the standpoint of good business practice it has been necessary to restrict our participation in activities such as yours principally to those legally required.[2]

Company I

The president of company I was most cooperative, but he had controlled this small company for such a short time that he had neither studied nor instituted any increases in size. He was relatively new to the business and had nothing to contribute to the material already acquired.

Company H

Company H, a small company, is a subsidiary of a firm that is not in the petroleum industry. The interview was conducted with the manager of the planning and economics

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[2]Name withheld by request.

department. The basic facilities have existed for some time and have been improved at regular intervals. A recent investment decision involving a Platformer (equipment which combines lighter fractions into gasoline) increased production of gasoline from 35 to 55 percent. The decision had to be "sold" to a tough-minded management on a return-on-investment basis. A postcompletion review of the operation disclosed it had met or exceeded expectations.

The firm has attempted to keep labor and operating costs below the industry average and to excel in station location and efficient station format. The basic marketing policy during the period under study has been to emphasize volume with a basic two-cent differential in price. One objective of this firm is to maximize the profit of the refining department. To accomplish this goal required a flexible computer-assisted evaluation of possible input and output combinations. This firm indicated a strong tendency toward short-short run product-mix flexibility.

Company G

The interview with Company G, a small company, was conducted with its president. The firm was formerly owned by another oil company and moved from a branded to an unbranded marketing position. It relied quite heavily on the small-business set-aside program to allow it to exist under the extreme pressure of recent years. Its pricing policy has been one cent under tank-wagon price and is exclusively wholesale except for the jet-fuel operation. The only expansion considered by this firm increased its capacity by 25 percent. Idle equipment was used to rework the units, and therefore an excellent return on investment resulted. This firm appears quite content to remain small.

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AN EMPIRICAL STUDY OF SELECTED CAUSES AND EFFECTS OF SEMIRIGID PRICES IN THE PETROLEUM REFINING INDUSTRY WITH EMPHASIS ON THE PERIOD 1963 THROUGH 1972

AN EMPIRICAL STUDY OF SELECTED CAUSES AND EFFECTS OF SEMIRIGID PRICES IN THE PETROLEUM REFINING INDUSTRY WITH EMPHASIS ON THE PERIOD 1963 THROUGH 1972

Abstract of dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

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The premise of this study is that certain policies within and without the petroleum industry have interacted to produce semirigid industry prices. One effect of this price rigidity is the inflexibility that is passed on to costs whenever the traditional joint-cost-accounting allocation (based on relative market value) is used in conjunction with these prices.

In studying the problem, activities and policies which combined to cause artificial price restraints in the petroleum-refining industry from 1963 to 1972 were reviewed. The accounting and economic implications and the effect on refinery investment of the resulting semirigid prices were investigated.

Published wholesale gasoline prices were compared with the wholesale price indexes from 1963 to 1972. The gasoline price trend was significantly different from the intense inflationary trend which began in 1964. A test of regression line slopes covering the inflationary period resulted in a rejection of the null hypothesis of slope similarity. Therefore, no adjustment for price-level changes was necessary.

A major reversal in the wholesale gasoline price trend was found to be centered on 1959, and appears to be caused by the Oil Import Program. Marginal cost pricing when discontinuities existed, coupled with industry policy rigidities, added to the undesirable effect of government involvement in the refined-products marketing picture. This involvement was further complicated by rigid policies and biases of other nonindustry groups.

Unyielding adherence by each group to policies that needed modification appeared to cause the price rigidities. Government officials pursued a low-cost-energy policy with a threefold effect: (1) A low-price natural-gas policy encouraged consumption and held competing product prices low. (2) Import restrictions on residual fuel oil were frequently reduced to maintain low prices, increasing import dependency. (3) The wholesale gasoline price was attacked from the two following sources when a disproportionate percentage of crude oil was allowed to marginal producers: (A) Government policies interacted with a marginal-cost pricing scheme to produce an unstable price-depressing effect in the industry. (B) The government then forced a rollback in price advances of refined products by threatening complete removal of import controls. These external interferences placed upward rigidities on price and drove the average return on investment for the industry below the national average for all manufacturers.

Uncertainties introduced by ecological considerations, along with the low return on investment, temporarily halted most new construction. Large companies changed from a policy favoring totally new refinery construction to one which balanced refinery facilities. Smaller firms continued to rely heavily on construction with used equipment to hold down investment costs.

Without modification, the economic models presented in the literature failed to explain the activities of an industry with all the outward appearance of an oligopoly. The refining industry appeared (for a limited time) to be unable to function as an oligopoly. The writer attempted to show the possible effects of government intervention by presenting two modified economic models. Both the conventional kinked-demand-curve approach and one designed to provide for external as well as internal constraints were considered.

A review of the price-relative joint-cost allocator disclosed a time interval during which this accounting allocator proved invalid. Inquiry revealed an industry trend toward the managerial use of a volume allocator rather than the price-relative cost allocator. The industry, now faced with extensive planning and control problems, will face even more pressing requirements for detailed accounting information. Thus it seems essential for the industrialist and the academicians to work together in striving for a more realistic solution to the cost-allocation problem, a solution which may be multi-staged.