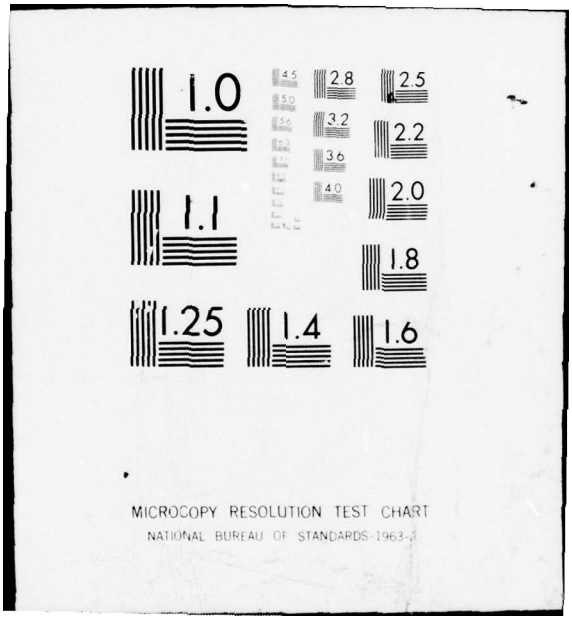
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Petroleum Regulation: The False Dilemma of Decontrol

Charles E. Phelps, Rodney T. Smith

R-1951-RC

January 1977



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PETROLEUM REGULATION: THE FALSE DILEMMA OF DECONTROL

CHARLES E. PHELPS RODNEY T. SMITH

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PREFACE

This report had its beginning in a brief investigation in September 1975 of the potential effects of decontrol of the oil industry. The controls originated in the Phase IV price controls, were modified by the Emergency Petroleum Allocation Act (EPAA) of 1973, and are administered by the Federal Energy Administration (FEA). They legally expired on August 31, 1975, but were retroactively reinstated in September and extended to November 15, and again to December 15, while the Congress and the President sought agreement on the nature of future controls on the petroleum industry. As the national debate grew wider, a more extensive study of the effects of controls was made at Rand, funded through corporate research funds. The resulting report focuses on the 1973 EPAA laws, but modifications are made as appropriate to accommodate the 1976 extension and certain legal changes.

As the study expanded, it became apparent that the subject was of considerably larger scope than that of price controls, and indeed extended into production technology, the nature of product demand, and the roles of tariff policy and world trade. In this report the authors attempt a comprehensive analysis of interrelationships between these forces as applied to the petroleum industry. They develop an analytical framework that they believe can be applied to price controls under a wide variety of conditions.

The report should be useful to persons interested in the effects of existing regulations administered by the FEA, in pricing policies and controls in general, and in interactions of domestic and world markets.

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SUMMARY

The petroleum industry in the United States remains bound by price controls originated in 1971 and recently extended until 1979 by the Energy Policy and Conservation Act (EPCA) of 1975. That extension was viewed as a way to combat higher prices for refined products, at the expense of increased U.S. dependence on foreign oil. While we concur that the extension did increase U.S. dependence, we believe that the controls have not reduced the prices of refined products. Consequently, decontrol does not pose a choice between higher product prices and less dependence. Rather, decontrol reduces dependence on foreign oil.

Existing controls regulate many aspects of petroleum production and refining in the United States. Domestic production of crude oil is subject to a three-tier price control. "Lower Tier Oil" is base-period output from properties producing in 1972. That oil can be sold at prices averaging about $5.15 per barrel. "Upper Tier Oil" is output from those properties in excess of the base-period production, as well as all output from properties beginning production since 1972. That oil can be sold for about $11.50 per barrel. Output from properties producing less than 10 barrels per day is exempt from price controls. In contrast, imported crude oil is subject to a tariff of $.21 per barrel, which, when coupled with price movements on the world market, has made the landed price of foreign crude oil approximately $14 per barrel.

The regulations also determine the price of controlled oil transferred to refiners. The "allocation program" distributes the controlled oil according to historical contracts in 1972. The "entitlement program" offsets differences in average acquisition costs arising from disparate access to controlled oil.

Product price ceilings administered by the Federal Energy Administration (FEA) are intended to force refiners to pass along to retailers the "savings" arising from the price controls on crude oil. The product price ceilings consist of base-period prices (from

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1973) plus allowable increases due to increased costs of refining (for example, higher prices of crude oil). Controls on retail prices are similarly intended to force retailers to pass to consumers the alleged savings.

Existing analyses, with which we agree, conclude that the crude oil price ceilings must certainly reduce U.S. crude oil production, and hence increase U.S. dependence on foreign oil sources.

Prevailing analyses also conclude that decontrol would increase the price of refined products by as much as 5¢ to 6¢ per gallon. That conclusion has been reached by two separate arguments. First, it has been assumed that refiners price their product on the basis of average acquisition cost of inputs. The controls have reduced these costs and by this logic have therefore reduced refined product prices. Second, the entitlement program, as described below, generates a subsidy on the use of crude oil in refining, so its repeal would increase refined product prices. Both conclusions are incorrect.

The average-cost pricing forecast is based upon an erroneous view of the world. Product prices are based upon the cost of producing the most expensive unit, not average costs. Since foreign oil is the most expensive, the price of refined products is based upon imported oil prices. Refiners of controlled oil receive a profit transfer from the producer of the oil, but those profits are retained by the refiner. The product price ceilings attempted to force refiners to pass on these profit transfers to consumers, but the price ceilings are not binding. Market forces in fact impose a greater discipline on refined product prices than do the FEA controls.

The structure of the price controls provides evidence that the price ceilings are indeed nonbinding. The FEA regulations allow refiners to accumulate "banked costs"--increases in average refining costs which are not taken in product price increases--for four product categories (gasoline, fuel oil, jet fuel, and other products). Any time banked costs are positive, product prices are not controlled, since prices could legally be increased. Data from the FEA show that

substantial banked costs exist, averaging 6¢ to 9¢ per gallon for the industry during 1975, drifting slightly downward during 1976. Our research has estimated that for every $1 per barrel (2.4¢ per gallon) increase in the world price of crude oil, refiners increase their product price by 28¢ per barrel (2/3¢ per gallon) less than is allowed by the FEA price controls. This attests to the rigorous discipline of the market.

While the price controls on crude oil did not influence product prices, they did transfer profits within the petroleum industry. In 1975, the crude oil price controls and allocation program transferred about $8 billion from crude oil producers to refiners. Since vertical integration is prevalent in the petroleum industry, much of this was a transfer between production and refining subsidiaries. However, at least $3 to $4 billion was transferred from crude oil producers to nonaffiliated refiners. Decontrol would eliminate these transfers.

The second forecast of a product price increase is based upon the effects of the entitlement program. This program requires that refiners have an entitlement for each barrel of controlled oil used in refining. Each firm is issued entitlements equal to their total use of crude oil multiplied by the industry average ratio of controlled oil to total oil. Some firms are issued fewer entitlements than their actual use of controlled oil would require. Such firms must purchase additional entitlements from other firms at a price determined monthly by the FEA. In 1975 the purchase and sale of entitlements transferred $1.5 billion among refiners.

Every refiner has an incentive to expand oil inputs (and hence output) to receive additional entitlements. By this logic, the expansion in domestic refining, which did occur, should have caused refined product prices to decline in the United States when the entitlement program was instituted in November 1974. Repeal of the program would reverse this hypothesized price decline.

This forecasted price increase neglects the presence of world trade in refined products. The United States has been an active participant in world markets for refined products for many years,

currently as a net importer. Because of this world trade, the domestic price of refined products is established by world, rather than U.S., demand and supply, with domestic prices conforming to landed world prices of products, inclusive of the current product tariff. By subsidizing domestic crude oil use, the entitlement program expanded domestic refining and reduced U.S. demand for product imports. U.S. refiner prices would decline, only if the reduced U.S. demand for product imports lowered world product prices.

Events after the introduction of the entitlement program showed that product prices did not decline. The entitlement program decreased the volume of product imports by 16 percent, but had *no discernible effect* on refiner prices reported by the FEA. In contrast, the 1.5¢ per gallon tariff on product imports has increased U.S. prices of refined products, adding to industry profits by $2 billion per year.

The 1975 EPCA allows the Administration to decontrol any or all parts of the petroleum and refining industries, subject to consent of the Congress. Selective removal of refinery price ceilings eliminates nonbinding controls and hence would have no effect either on product prices or dependence on foreign oil. Total decontrol of oil production, allocation, refinery price ceilings, and entitlements would also have no effect on product prices, but would reduce dependence on foreign oil. However, reduction or abolition of the product tariff would reduce refiner prices. Thus the opportunities for decontrol written into the EPCA present a political challenge to the new Administration. The choice is reduced dependence on foreign oil or continuation of the current multi-billion-dollar transfers within the industry.

ACKNOWLEDGMENTS

We are indebted to Donald B. Rice, President, and Fred S. Hoffman, Energy Program Director, of The Rand Corporation, for providing funds to support this research. We are grateful to James P. Smith, also of Rand, for a most insightful review of previous drafts of this report. We have also benefited from reviews by Morris Adelman (MIT) and Arthur J. Alexander (Rand) and from discussions with Michael Caines (American Petroleum Institute), Stephen W. Chapel (Rand), John F. Cogan (Rand), and Michael Ward (UCLA). Lloyd S. Shapley (Rand) provided useful insights into the noncooperative game regarding the entitlements program. Any remaining errors are the authors' alone.

CONTENTS

PREFACE iii

SUMMARY v

ACKNOWLEDGMENTS ix

Section
I. INTRODUCTION 1

II. RECENT HISTORY OF PETROLEUM INDUSTRY CONTROLS 3
U.S. General Price Controls--A Precursor to Petroleum Controls 3
Specific Petroleum Industry Controls 3
Modifications Arising from the 1975 EPCA 8
Summary 8

III. A STYLIZED MODEL OF MARKET EQUILIBRIUM 11
OPEC Cartelization and the Price of Refined Products ... 11
Domestic Market Effects 16

IV. PRODUCT PRICE REGULATION 19
Product Price Ceiling 19
Profit Margin Regulation 23
Empirical Evidence on the Nonbindingness of Product Price Controls 24
Statistical Analysis of Banked Costs 24

V. THE ENTITLEMENT PROGRAM 34
A Behavioral Model 34
Economic Effects 38

VI. THE ALLOCATION PROGRAM 47

VII. DOMESTIC OIL PRODUCTION 50
The Theoretical Case: 1973 EPAA 50
The Empirical Case: 1973 EPAA 53
The 1975 EPCA--Unambiguous Reduction of Crude Oil Production 54

VIII. U.S. POWER IN WORLD MARKETS FOR CRUDE OIL AND REFINED PRODUCTS 58
Empirical Evidence That the United States Has Little Power in World Product Markets 58
U.S. Market Power 59
The Repeal of the Entitlement Program 61
Tariff Policy 65

IX. WHAT THE CONTROLS DID ACHIEVE 69
Summary 69
Unresolved Issues 71

Appendix 73

BIBLIOGRAPHY 89

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I. INTRODUCTION

The petroleum industry in the United States remains regulated by price controls originated in 1971, and those controls were recently extended until 1979 by the Energy Policy and Conservation Act (EPCA) of 1975. Extending the controls was viewed as a way to combat higher prices for refined products, at the expense of increased U.S. dependence on foreign oil.[1] While we concur that the extension increased U.S. dependence, we will show that the controls have not reduced the prices of refined products, but did redistribute as much as $5 to $6 billion annually among crude oil producers and refiners. Consequently, the issue of decontrol of petroleum prices is not a dilemma between higher product prices and less dependence, but is a political contest between those who support reduced dependence versus those who benefit from the transfers.

In assessing the impact of the price controls, we will limit our discussion to price levels of petroleum products and to the distribution of industry profits among the independent and the vertically integrated crude oil producers and refiners. By thus limiting our discussion, we make no attempt to analyze the optimal path of petroleum prices in the United States over time, the welfare effects of various policy alternatives, or the desirability (or undesirability) of wealth transfers between firms in the petroleum industry or between petroleum firms and consumers.

While this report focuses on the petroleum industry, we believe that there are general lessons to be derived from the analysis that would apply to price controls of other industries or for a total economy. We have attempted to structure the basic theoretical arguments for our analysis in a sufficiently general manner to provide insights not dependent upon particular institutions of the petroleum industry.

The plan of the report is as follows: We present a brief history of the industry controls, to provide institutional and technical background for the analysis (Sec. II). We then develop a stylized theory

of market equilibrium to be applied to the world and to U.S. product markets (Sec. III), focusing on how factor price changes might alter equilibrium product prices. With this setting, we examine the product price controls administered by the Federal Energy Administration (FEA) (Sec. IV) and compare the prices that those controls allow with those reached by the market solution.[2] In Sec. IV, we also present evidence to show that the U.S. price controls on refined products have not been binding at the refinery level for the duration of the controls as administered by the FEA. Section V analyzes the economic effects of the entitlement program, which was designed to redistribute profits among refiners. We show that unintended effects of this program also led refiners to alter production in an inefficient manner. We next examine the allocation program, which distributed price-controlled oil (Sec. VI) and the production effects of those price controls (Sec. VII). We assess the sensitivity of our results to the maintained assumption that the United States has no significant market power either in world crude oil or in refined product markets (Sec. VIII). The final section summarizes what we believe to be the important effects of the FEA regulations. A mathematical appendix provides derivations for results in the study.

FOOTNOTES

[1]Government analysts had forecast a 5¢ to 8¢ per gallon increase in the price of the refined products upon decontrol (see, for example, U.S. Senate (1975b). Similar qualitative predictions were made by Helbling and Turley (1975) and by Friedman (1975b).

[2]The FEA was originally the Federal Energy Office (FEO). For convenience, we use the current term throughout this report.

II. RECENT HISTORY OF PETROLEUM INDUSTRY CONTROLS

U.S. GENERAL PRICE CONTROLS--A PRECURSOR TO PETROLEUM CONTROLS

On August 15, 1971, the President announced a general price freeze throughout the economy to combat widespread and accelerating inflation. While we do not view control of relative prices between products as a useful mechanism for controlling inflation, the structure and implementation of the economy-wide controls provide considerable insight into the current oil price control mechanism. Phase I, a general price freeze, terminated on November 14, 1971. Its successor, Phase II, continued through January 11, 1973, and is historically important because it established the precedents of profit margin controls and allowable price increases based on cost increases. On May 6, 1972, small refiners and many crude oil producers were exempted from the controls under the general Small Business Exemption, reflecting a political concern for small refiners that had earlier been demonstrated by the structure and operation of the oil import quota schemes (Dam, 1971).

The single petroleum industry "problem" arising out of the Phase II controls occurred just at its end. Since relative prices *within* the refining industry were frozen as of the summer of 1972, the usual incentives were missing for refiners to shift production away from gasoline towards heating oil as winter approached. With extreme cold weather in some parts of the country in late 1972, fuel oil shortages emerged. Thus Phase II precipitated a problem that was left for Phase III administrators to solve.

SPECIFIC PETROLEUM INDUSTRY CONTROLS

Phase III controls were characterized by voluntary compliance with control guidelines which were themselves less binding than those of Phases I and II. Particularly in the home heating oil market, substantial price increases were observed as markets eliminated excess demand. In February, 1973, the Cost of Living Council began

hearings from which would emerge the price-control structure now imposed on the petroleum industry. The staff paper summarizing these hearings urged more complete, unified control on the industry, including mandatory pricing standards.[1] On March 6, 1973, the Cost of Living Council issued Special Rule No. 1, reimposing mandatory price controls on sales of crude oil and refined products by any firm with annual gross sales of $250 million or more (24 firms were affected). This rule allowed product price increases of up to 1 percent without justification, increases of up to 1.5 percent (annually) corroborated by cost increases, and increases over 1.5 percent subject to a profit margin constraint. Special Rule No. 1 was a spectacular failure as a price-control device--gasoline prices (as measured in the Consumer Price Index) rose 33.2 percent and fuel oil prices rose 37.5 percent during the six months of Phase III when Special Rule No. 1 was operative.[2]

Both the petroleum industry and price-controllers evidenced immediate dissatisfaction with Special Rule No. 1. Staff members of the Cost of Living Council continued to seek new devices to hold down petroleum prices and congressional attention focused on petroleum pricing and allocation problems. As early as April 13, 1973, the "Emergency Fuels and Energy Allocation Act of 1973" was introduced into the Senate and passed with amendments on June 5 (U.S. Senate, 1975a). By autumn, the President had apparently decided on a direct allocation plan to counteract further winter heating problems,[3] but congressional action was precipitated by the outbreak of the 1973 Arab-Israeli War on October 6. The war immediately reduced shipments of crude oil from the Middle East, although no formal boycott was announced by the Arabs until October 18. On October 17, the House of Representatives passed the Senate bill, with modifications, and a conference bill (the Emergency Petroleum Allocation Act (EPAA) of 1973) was passed on November 14 by the Congress and was signed by the President on November 27.

This law remained unchanged for two years (although several important administrative changes occurred) and was due to expire in August 1975. Short-term extensions of that law occurred twice in the fall of 1975 while the Congress debated the contents of the

Energy Policy and Conservation Act (EPCA) of 1975, which was eventually passed and signed by the President in December. The EPCA extended the controls for an additional 40 months, modifying the structure slightly. We next describe the regulations as derived from the 1973 EPAA and its predecessor price controls, and we then discuss the modifications arising from the 1975 EPCA.

Crude Oil

The initial Phase IV regulations placed controls on crude oil and refined products but did not assign to buyers the property rights to controlled oil. The Phase IV mandatory controls began operation on September 1, 1973, and established pricing provisions for both crude oil and for refined products.

Four classes of crude oil were established. "Old Oil" was the term applied to the level of production from each specific property month by month during 1972. That quantity of oil from each property was required to be sold at the posted price on May 15, 1973. (Later additions of 35¢ and $1 led to the 1975 average of $5.25 for Old Oil.) "New Oil" was the term given to any further production from each property and could be sold at uncontrolled prices. The production of New Oil enabled the property-owner to sell an equal amount of Old Oil at the uncontrolled price; that quantity of Old Oil was termed "Released Oil."[4] All production from properties not producing oil in 1972 was considered as New Oil. "Stripper Oil" designates oil from properties producing under 10 barrels per day and could be sold at uncontrolled prices.

The rules failed to establish any mechanism for allocation of property rights to a valuable commodity--a factor of production priced by law below its true economic value. During Phase IV controls, rumors were rampant about tie-in sales of Old and New Oil, with New Oil prices allegedly rising to $25 per barrel or more (Owens, 1974). One refiner was alleged to have paid $50,000 for one barrel of New Oil to obtain some Old Oil. Without confirming or denying these rumors (we have no basis to comment upon them), it

seems apparent that such activity must have persisted in some forms, because the Phase IV program created a true economic shortage for Old Oil without describing a system for its allocation. With the Arab-Israeli War and subsequent boycotts of crude oil shipments to the United States, congressional concern shifted to the allocation of crude oil among refiners as well as of products among consumers.[5] The mechanism required by resulting legislation (1973 EPAA) was to freeze all contracts within the petroleum industry at a given point in time. The EPAA established property rights to valuable Old Oil by giving those rights to the refiners purchasing that oil on December 1, 1973.

Refiners

Phase IV established a price ceiling on refined products that is still in existence today. The price ceiling established base-period prices for refined products (as of May 15, 1973), allowing ceiling prices to rise on the basis of increased product import costs and with increases in the price of crude oil. Crude oil price increases were spread across refined products based upon volume-of-output ratios, thus providing an arbitrary administrative solution to the problem of allocating joint production costs to several products.[6] The formulas for pricing various products allowed cost increases that were not taken during a given month ("banked costs") to be applied to price ceilings in future months. Banked costs were accumulated for three separate categories of products (gasoline, fuel oils, and other products), and were reported by each refiner.[7]

Retailers

For refined petroleum products, the initial Phase IV regulations placed an absolute ceiling on retail product prices, in stark contrast to the more flexible cost-passthrough ceilings characterizing earlier regulation throughout the economy. On September 28, 1973, just a week before the Arab-Israeli War began, the allowable retail price was established to be the May 15, 1973, price plus any cost increases occurring between May 15 and September 28. A month later,

the rule was again changed to allow dollar-for-dollar passthroughs of costs, but *only once monthly*. When the Arab boycott (October 18) reduced world crude oil supply, world crude oil and refined product prices increased dramatically.

The FEA regulations introduced lags between cost increases and allowable price increases and thus created substantial gaps between available supply and the quantity demanded at posted prices. Since no property rights had been established at the retail level (although rationing tickets were often proposed), queues were the only readily available allocating device. Often motorists waited more than an hour to buy gasoline in most American cities. This provided one of the most strikingly visible demonstrations of the existence of shadow prices in recent memory.

The Entitlement Program

Since Old Oil was allocated on the basis of historical domestic contracts, there was inevitably a substantial disparity between the amounts of Old Oil accessible to various firms. It was believed that firms with access to relatively large amounts of Old Oil enjoyed a "competitive advantage" over other firms.[8]

Firms with the highest fractions of Old Oil tended (although not exclusively) to be larger, vertically integrated firms producing much of their own oil. Concern for the existence of firms without access to Old Oil led to the implementation, in late 1974, of the "entitlement program."

Under the entitlement program, each refiner is issued the rights to use a certain amount of Old Oil each month, the amount being determined by the refiners' total oil use multiplied by the *industry* fraction of Old Oil to total oil inputs (which was approximately 0.4 for 1974-1976). The price of an entitlement is set monthly by the FEA and equals the difference between average costs of all uncontrolled oil and the average cost of controlled oil. Firms issued fewer entitlements than actual Old Oil quantities used are required to purchase additional entitlements from other refiners at the FEA announced price. Small refiners are allowed to apply for exemption from this obligation.

Tariffs

During early 1975, concern arose regarding U.S. dependence on foreign crude oil, as domestic production of crude oil had been falling steadily since 1970. Partly in response to these concerns, the President, in January 1975, established a supplemental fee of $1 per barrel in addition to the 21¢ per barrel license fee existing since May 1973. The supplemental fee was raised to $2 in May 1975.[9] Despite legal challenges to the President's authority to impose the supplemental fee, it remained in effect until January 1976, at which time it was removed when the EPCA of 1975 was signed.

MODIFICATIONS ARISING FROM THE 1975 EPCA

The 1975 EPCA made a single basic alteration and several minor accounting adjustments in the controls. The major alteration was to set a price ceiling on previously uncontrolled New Oil at approximately 10 percent below world market prices (Stripper Oil remained uncontrolled). The 1975 law also did away with the provision for Released Oil. The base-period production level for properties producing Old Oil was changed to 1975, rather than 1972 month-by-month production levels.

To accommodate the new price provisions, entitlements became allocated upon a weighted industry average of Old plus New domestic oil relative to total consumption, instead of the domestic use of Old Oil to total oil.

SUMMARY

As of late 1976, the U.S. petroleum industry is operating under laws and regulations that (a) set a price ceiling for a substantial fraction of domestic crude oil production and control the allocation of that oil to specific refiners; (b) levy tariffs for the importation of both crude oil and refined products; (c) provide formulas establishing a price ceiling for refined products, based on historical prices and on factor price increases; (d) reallocate profits between refiners via the entitlements program; and (e) establish maximum allowable prices for refined products at the retail level.

In subsequent sections, we will analyze the effects of the crude oil and refining regulations on industry behavior.

FOOTNOTES

[1]Owens (1974), p. 1241.

[2]In Sec. III we show the conditions under which the type of constraint implied by Special Rule No. 1 will not be binding.

[3]Cowan (1973).

[4]Released Oil could initially be sold at a price between that of Old Oil and New Oil, and later at uncontrolled prices.

[5]*New York Times* (1973).

[6]Alchian and Allen (1969) discuss the impossibility of uniquely allocating joint costs.

[7]Section IV discusses the importance of banked costs. Changes in the law in 1975 now require a fourth category of banked costs for jet fuel.

[8]The concept of a competitive advantage has not been well defined. If the concept is meant to imply a lower marginal cost of production (because of access to Old Oil), there exists no differential advantage, since the marginal cost of oil is the same for all firms. If the concept implies higher profitability, then we concur that the concept has meaning (because of economic rents on Old Oil), so long as the Old Oil is acquired from a separate firm. The concept does not apply for a vertically integrated firm, because the transfer is from within rather than outside the firm.

[9]The license fee was originally 10.5¢ per barrel on May 1, 1973, and rose to 21¢ by May 1, 1975, where it has remained. Fees were also levied on product imports. Gasoline import fees were originally

52¢ per barrel, and rose to 63¢ by May 1, 1975. Other finished product fees were originally 15¢ per barrel and are now 63¢.

III. A STYLIZED MODEL OF MARKET EQUILIBRIUM

As a basis for later analysis, we study the relationship between factor and product prices. We present a model of refining with two factors of production: crude oil and an aggregate of other factors. Both factors are assumed to be specific to the world petroleum industry. Refined products and crude oil are assumed mobile in international markets. The amount of U.S. power in these markets becomes an important issue in later analysis and warrants special consideration in Sec. VIII.

Our explicit modeling simplifies many visible characteristics of the industry. We discuss refined products as an aggregate commodity rather than as many related product markets. We disregard the different qualities of crude oil. We assume a simple production technology that ignores jointness and potential non-homotheticity. We do not present an explicit spatial model of the petroleum industry but concentrate on a single world price for crude oil and refined products. However, we do consider transportation costs in the foreign supply of crude oil and refined products to the United States.

We do not deny that the above characteristics must be included in a more comprehensive study of petroleum regulation. We simplify our model, however, to highlight forces that are fundamental to ascertaining the economic effects of this regulation. These economic forces are present, whatever the characteristics of the industry. Our modeling effort could be extended to incorporate the omitted characteristics but only at the expense of severely complicating, but not changing, our interpretation of primary economic forces.

OPEC* CARTELIZATION AND THE PRICE OF REFINED PRODUCTS

We first determine how OPEC cartelization would have influenced

*Oil Producing and Exporting Countries.

the price for refined products in the absence of petroleum regulation by the United States. The uncontrolled market represents a base case that regulation attempted to modify. The results from this exercise provide useful information for our assessment of the product price ceiling and the profit margin constraint imposed by domestic regulation.

We characterize cartelization as OPEC's increasing the tax on their exports of crude oil. It is well known from trade literature that the net revenue-maximizing, *ad valorem* tax is equal to the reciprocal of the elasticity of demand for OPEC exports. We do not discuss whether actual OPEC pricing policy adopts this optimum tax, nor do we consider reasons why OPEC increased the tax; for our purposes it is sufficient to summarize OPEC pricing decisions as an increase in their export tax.

The following model derives how the increased export tax affects the price of refined products in an uncontrolled world market. A modified version of the model will also be used to study the effects of U.S. regulation on factor and product prices. The given elements of the model are product demand, factor supplies, and the production technology for refined products. Except for the OPEC tax, the model does not explicitly consider trade interventions. The presence of interventions will influence the elasticities for product demand, and factor and product supply. (Explicit analysis of trade interventions is pursued in our discussion of petroleum regulation by the United States.)

World demand for refined products is inversely related to the world price:

$$Q^* = \eta P^* \tag{3.1}$$

where η is the elasticity of demand, Q is the quantity of refined products, and P is the world price. An asterisk (*) denotes the percentage change in each variable.

The world supplies of factors A and B are directly related to their world prices, reflecting the specificity of these factors to

the world petroleum industry. In the partly cartelized crude oil market, supply is:

$$A^* = (1 - S)\varepsilon_A w_A^* + S \frac{\varepsilon_A}{(1 + T)} (w_A^* - \delta T^*) \qquad (3.2a)$$

The other factor supply is:

$$B^* = \varepsilon_B w_B^* \qquad (3.2b)$$

where ε_i is the ith factor's supply elasticity, factor A is crude oil, factor B is the other factor of production, w_i is the ith factor's price, S is the market share of the OPEC cartel, T is the *ad valorem* export tax imposed by OPEC, and $\delta = T/(1+T)$.[1]

The production technology for refined products is represented by the input/output coefficients (a and b) for each factor. To simplify the discussion, the production technology is assumed to display constant returns to scale.[2] These input/output coefficients depend only upon relative factor prices, illustrating the potential for factor substitution. The input/output coefficients change according to:

$$a^* = \alpha_B \sigma (w_B^* - w_A^*) \qquad (3.3a)$$

$$b^* = \alpha_A \sigma (w_A^* - w_B^*) \qquad (3.3b)$$

where α_i is the ith factor's cost share and σ is the elasticity of factor substitution, which is positive.[3]

The constant returns to scale assumption implies that product revenue equals factor payments. Because of this accounting identity, it must be true that the percentage change in product price is a weighted average of the percentage changes in the factor prices, the weights being each factor's cost share,[4] i.e.:

$$P^* = \alpha_A w_A^* + \alpha_B w_B^* \tag{3.4}$$

Equations (3.1) to (3.4) can be solved for the relationship between the OPEC export tax and the prices for factors and refined products. The solutions for the factor prices are:[5]

$$w_A^* = \left[\frac{\varepsilon_B + \alpha_A\sigma - \alpha_B\eta}{\Delta}\right] \cdot \left[\frac{S\delta\varepsilon_A}{(1+T)}\right] \cdot T^* > 0 \tag{3.5a}$$

$$w_B^* = \left[\frac{\alpha_A(\sigma+\eta)}{\Delta}\right] \cdot \frac{S\delta\varepsilon_A}{(1+T)} \cdot T^* \gtrless 0 \text{ as } (\sigma+\eta) \gtrless 0 \tag{3.5b}$$

where Δ is the determinant of the excess supply functions for the factors A and B.[6] From this model, the following conclusions may be drawn. (1) The increased export tax raises the world price of crude oil (see Eq. (3.5a)). (2) The increased tax has an ambiguous effect on the price of the other factor (see Eq. (3.5b)). The increased price of A leads refiners to use factor B more intensively to produce any given quantity of refined products. This exerts upward pressure on the price of B. In Eq. (3.5b) this effect is captured by the term with the elasticity of substitution σ. However, the lower equilibrium level of industry output places downward pressure on the price of B. This effect is shown by the term with the elasticity of product demand η. The increased export tax reduces the equilibrium price for B if consumers are more willing to substitute between refined products and other goods than producers are able to substitute between crude oil and other factors of production, i.e., if $(\sigma + \eta) < 0$.

The increased export tax leads to a higher equilibrium price for refined products, since

$$P^* = \frac{\alpha_A(\varepsilon_B + \sigma)}{\Delta} \cdot \frac{S\delta\varepsilon_A}{(1+T)} \cdot T^* > 0 \tag{3.6}$$

$$= \varepsilon_q \cdot \frac{S\delta\varepsilon_A}{(1+T)} \cdot T^*$$

where ε_q is the elasticity of supply of refined product.

For the purpose of later analysis of product price regulation (Sec. IV), it is useful to compare the magnitude of the price rise in Eq. (3.6) with the change in the price of crude oil multiplied by oil's initial input/output coefficient. This comparison is simplified by rewriting Eq. (3.4) in terms of absolute changes:

$$dP = a_o dw_A + b_o dw_B \tag{3.7}$$

where a_o and b_o are the input/output coefficients prevailing at the initial export tax. Equation (3.7) clearly shows that if the increased export tax reduces the price of the other factor, then the product price increases by less than the change in the price of factor A (crude oil) multiplied by its initial input/output coefficient a_o.

The above analysis is applicable for small changes in the export tax. Large increases in the export tax require modifications.[7] The primary modification considers changes in the input/output coefficients a and b.[8]

The percentage changes in a and b are:

$$a^* = \frac{\alpha_B \sigma[\eta - \varepsilon_B]}{\Delta} \cdot \frac{S\varepsilon_A \delta}{(1 + T)} \cdot T^* \lesseqgtr 0 \text{ as } \sigma \gtreqless 0 \tag{3.8a}$$

$$b^* = \frac{\alpha_A \sigma[\varepsilon_B - \eta]}{\Delta} \cdot \frac{S\varepsilon_A \delta}{(1 + T)} \cdot T^* \gtreqless 0 \text{ as } \sigma \gtreqless 0 \tag{3.8b}$$

For large changes in T and $\sigma > 0$, the correctly calculated change in the product price would use input/output coefficients that lie between the initial and new coefficients. The appropriate coefficients place a lower weight on the increased price of crude oil and a higher weight on the change in the other factor price when computing P^*. If the increased export tax reduced the price of the other factor, then the use of the original input/output coefficients further

overstates the equilibrium change in the price of refined products. Alternatively, if the increased export tax increases the price of the other factor (i.e., if $(\sigma + \eta) > 0$) then the error from using the original input/output coefficients is ambiguous.

DOMESTIC MARKET EFFECTS

To this point, our discussion has focused on a world market for crude oil and refined products. Figure 1 depicts the effects of the increased OPEC tax on an uncontrolled domestic market (e.g., the United States). For illustration, we assume that the United States is a price-taker and a net importer in both crude oil and in refined product markets. The OPEC tariff increases the price of crude oil and the marginal costs of refining in the United States, as well as the product price. Hence, U.S. domestic crude oil production would rise, from A_1 to A_2, crude oil imports would fall, from $(A_4 - A_1)$ to

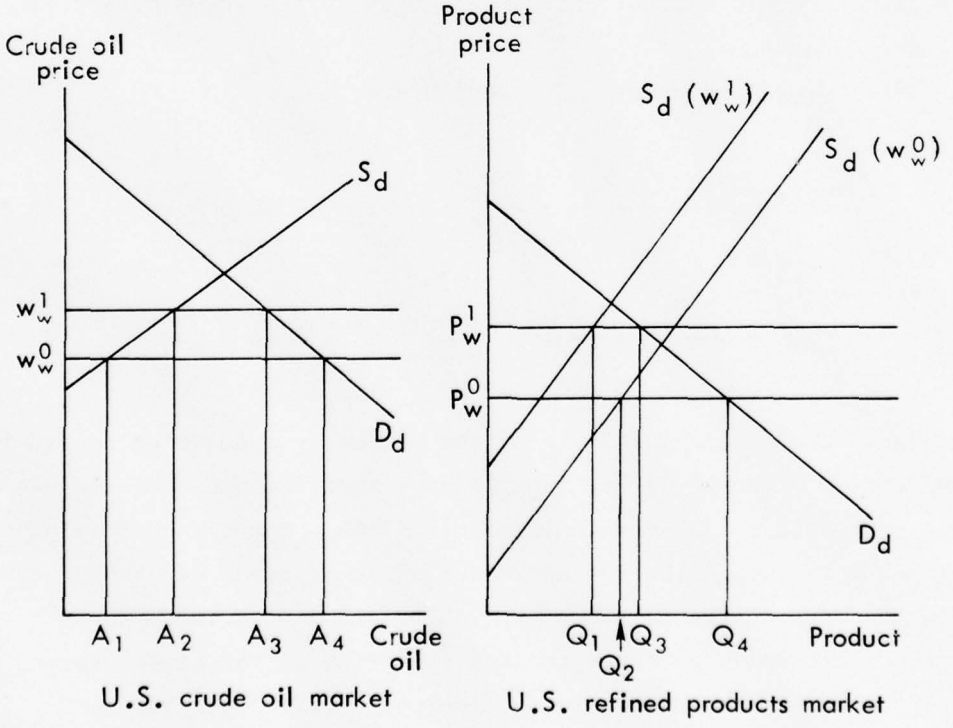


Fig. 1 — The impact of an increase in the OPEC tax on crude oil on U.S. crude oil and refined products markets

($A_3 - A_2$), domestic refining would decline from Q_2 to Q_1, domestic quantities demanded would decline from Q_4 to Q_3, but the effect on refined product imports would be indeterminate, depending on whether domestic consumption declined by more or less than domestic refining. Profitability (return to specific factor owners) would rise in the crude oil industry, would fall in the refining industry, and would be indeterminate in vertically integrated firms, depending on relative shares of the crude oil and refining subsidiaries.

Domestic regulation attempted to mitigate the impact on U.S. markets. Direct controls sought to limit the increase in refined product prices. Price ceilings on crude oil tried to transfer to refined product prices a portion of the increased profits from crude oil production. The following sections analyze the economic effects of these programs.

FOOTNOTES

[1]Equation (3.2a) is derived by logarithmically differentiating the supply for A with respect to the world price and the *ad valorem* tax. Note that export taxes have two effects on factor supply. First, the elasticity of factor supply is reduced. Second, increases in the tax reduce the supply of the factor to the world market.

[2]The analysis can easily be extended for production functions with decreasing returns to scale by introducing a third factor that is fixed to each firm. With this third fixed factor, decreasing returns to scale can be generated, even if the production function with the hired and the firm-specific factors displays constant returns to scale. See Razin (1974) for this characterization of decreasing returns to scale.

[3]See Jones (1965) for derivation of Eqs. (3.3a) and (3.3b).

[4]When there are decreasing returns to scale, the net receipts of the firm would be imputed as payments to the firm's fixed factor. The price of the fixed factor could be interpreted as profit per

unit of output. The analog to Eq. (3.4) would state that product revenue equals the sum of factor payments plus (residual) profits. An equation analogous to Eq. (3.5) would exist for return to fixed factors, showing that the residual return would depend upon product demand, elasticities of substitution, and the elasticities of supply of factors A and B.

[5]The factor price equations were derived as follows. Factor demand curves were derived by adding Eq. (3.1) to both Eq. (3.3a) and Eq. (3.3b). Equation (3.4) was used to substitute for the product price. Factor market equilibrium required that the resulting factor demands be equated to factor supply, Eqs. (3.2a) and (3.2b).

[6]This determinant is assumed positive, implying that the factor markets satisfy Hicks' condition for perfect market stability (Hicks, 1938).

[7]OPEC substantially increased its export tax during 1973 and 1974. World oil prices rose from $2 to $12 per barrel.

[8]It is well known that the cost share for factor A rises (falls) when the elasticity of factor substitution σ is less (greater) than unity.

IV. PRODUCT PRICE REGULATION

Domestic regulation imposed price ceilings and profit margin constraints in an effort to limit the increase in product prices. A binding control policy must satisfy two conditions. First, the allowed increase in the product price must be less than the price increase occurring in world markets. Second, export controls must be placed on the controlled product. If U.S. price regulation had satisfied both of these conditions, the regulation would have established a true economic shortage. Rationing of the controlled product would then have become a problem. Theoretical analysis of this problem can be found elsewhere (Barzel, 1974) and will not be discussed here.

PRODUCT PRICE CEILING

According to the refined product price ceiling, product prices can exceed that of their base period only by incurred increases in average costs of crude oil. Base-period prices are those charged on May 15, 1973, with several minor exceptions.[1] Incurred cost increases may be passed through only according to the following formula:[2]

$$P_{ci}^{t} = \frac{Q^{t}A^{t}R_{i}^{t} + B_{i}^{t} + G_{i}^{t} - H_{i}^{t}}{q_{i}^{t}} \tag{4.1}$$

where P_{ci}^{t} is the allowable increase above the base price for product i in month t.

Q^{t} is the total quantity of crude oil used in refining in month t.

R_{i}^{t} is a three-month moving average of the ratio of the volume of product i to total sales volume for all refined products.

A^t is the average increase in acquisition cost of crude oil above May 1973 costs.

B_i^t is the increase in world price of imported refined products of type i, during month t, multiplied by the base-period import volume of product i.

G_i^t is previously incurred costs that did not result in increased product prices (banked costs).

H_i^t is cost increases incurred for product i but taken for some other product in month t.

q_i^t is the amount of product i sold in month t.

The primary notion of the formula, with exceptions discussed below, is that the price of refined products cannot increase by more than the change in the price of crude oil multiplied by crude oil's initial input/output coefficient. Price changes for all other factor inputs *except return to capital* are treated similarly to "product costs." In the refinery industry controls, the "excluded factor" is capital. In essence, when the price of crude oil differs from its base price, the allowable change in the product price (ignoring cost increases shifted across products and refined product import costs) is

$$dP_c = a \cdot dw_A \tag{4.2}$$

This price ceiling need not be binding (compare Eq. (4.2) with Eq. (3.7)). The discussion surrounding Eq. (3.7) concluded that the price of refined products could have increased by less than the change in the price of crude oil multiplied by its initial input/output coefficient. If the elasticities of product demand and factor substitution sum to less than zero, then the change in the world price of refined products is less than the price increase allowed by the controls. This condition is quite likely to hold for the refining industry, since there is a strong presumption that $\sigma \simeq 0$.

This may be inferred because the input/output coefficient, a, has remained virtually at unity for a wide range of crude oil prices.[3]

Whenever a factor of production is omitted from the definition of a price ceiling, the bindingness of the control depends upon consumer tastes and production technology and cannot be specified *a priori*. One may think of there being a bias in the price control formula when factor B is omitted. The sign of the bias is determined by the sign of $(\sigma + \eta)$. The magnitude of the bias depends upon the size of $(\sigma + \eta)$ and the size of the factor cost share α_B. If $(\sigma + \eta)$ is less than zero, the larger the cost share for B, the further the controls are from being binding. If no factors are omitted from the price ceiling equation, then the controls mimic market forces.

There are other circumstances that influence the bindingness of the price control, even if $(\sigma + \eta)$ is less than zero. Rising real income increases the uncontrolled product price at a faster rate than the product price ceiling, if the controlled product is a normal good. Increased income increases the equilibrium price for both factors of production, but the price ceiling formula allows only the higher price for A to increase the price ceiling.

General inflation also increases the tendency for the price ceiling to become binding. Inflation leads to a proportionate change in the nominal prices for all factors and the product. The price ceiling must increase by a smaller amount with general inflation because of the omitted factor prices. On net, with both general inflation and rising real prices of factor A, the issue becomes whether or not the nominal price of B rises or falls.

Alternatively, productivity growth and increased supply of factor B increase the tendency of the price ceiling to be nonbinding. Productivity growth reduces the effective price of factors. Increased supply of factor B also reduces the price of B. The formula for the product price ceiling captures neither of these effects.

There are noteworthy elements of the price ceiling that are

peculiar to the petroleum industry but important for the bindingness of the price ceiling. The most distinctive features pertain to the calculation of average factor costs and to the treatment of increases in the import price for refined products.

The cost passthrough formula allows only a fraction of the increase in the true economic cost of crude oil to enter the pricing formula. Empirically, we can show that approximately two-thirds of the true factor cost increases are allowed to enter the product pricing formula.[4] By allowing increases only in the *average* acquisition cost of crude oil to enter the product pricing formula, the acquisition cost and the opportunity cost of crude oil are confused. This confusion reduces the tendency of the price ceiling to become nonbinding.

Ironically, the tariff on crude oil increases the tendency for the price ceiling to become nonbinding. The tariff (reaching as high as $2.21 per barrel) increases the acquisition costs of both New Oil and imported oil for domestic refiners, both of which increases are allowable price increases in the product pricing formula. However, this increased factor cost is borne entirely by domestic refiners under the assumption that the United States is a price-taker in the world market for products.[5]

Finally, the formula's treatment of increases in the import price for refined products is an exercise in double-counting. The impact of higher crude oil prices on product prices is determined in world markets, so that the portion of the formula relating to average crude oil costs already accounts for consequent movement in world product prices. The separate portion of the cost passthrough formula for increases in import product prices (B_i^t in Eq. (4.1)) is double-counting and provides further tendencies for the controls to become nonbinding.

In summary, the price ceiling imposed by FEA regulations can allow larger increases in product prices than would be sustained in an uncontrolled market. The presence of banked costs, as discussed below, confirms that the price ceilings have been nonbinding

since 1974. Whether the price controls will remain nonbinding depends upon the future course of the price of crude oil, growth in the world economy, the rate of inflation, productivity growth in refining, and the growth in the supply of non-crude oil factors of production.

PROFIT MARGIN REGULATION

The price regulations also impose profit margin constraints on refiners. These constraints allow product price increases only if profit margins do not exceed base-period levels. Two separate tests show that the profit margin constraint is also not binding.

Profit margins are defined to equal the ratio of "net revenue" to total revenue. In the usual application of this concept, payments to certain factors (e.g., capital) are excluded from definitions of cost, so that payment to these factors becomes net revenue. In the context of the two-factor model of production, the profit margin is the cost share for factor B.

Manipulation of formulas in Sec. III shows that the cost share for factor A rises when w_a rises, so long as there is low opportunity for factor substitution ($\sigma < 1$).

$$\alpha_a^* = \frac{(\sigma - 1)\ (-\varepsilon_B + \eta)w_a^*}{\varepsilon_q - \eta} \tag{4.3}$$

Under these same conditions, the cost share for factor b--the profit margin--must fall. We inferred earlier that $\sigma \simeq 0$, which implies that the profit margin controls will not be binding, because α_B falls as w_a rises.

Statistical analysis presented below shows that $(\sigma + \eta) < 0$. Coupling this with extraneous data from Kennedy (1974) that the product demand elasticity is less than unity, we have an independent inference that $\sigma < 1$. Indeed, so long as demand is inelastic (a sufficient, but not necessary condition), profit margin controls are nonbinding whenever $(\sigma + \eta) < 0$.

EMPIRICAL EVIDENCE ON THE NONBINDINGNESS OF PRODUCT PRICE CONTROLS

There are two types of evidence supporting our contention that the cost passthrough formula creates economically irrelevant price ceilings in the United States. First, the United States continues to import refined products (see Table 6, p. 41). If the price ceiling were an effective constraint, then no importer would be willing to pay the world market price, only to sell the product at a lower domestic price. Below we discuss the time pattern of U.S. product imports and present evidence that these imports are not all based upon long-term contracts. Rather, importers are able to adjust to changes in economic incentives.

Other evidence derives from the actual structure of the price controls. Banked costs, increases in "average costs" that are not recouped in the market by higher product prices, represent the difference between legal maximum and actual levels of product prices. As shown in Table 1, the aggregate level of banked costs amounts to 6¢ to 9¢ per gallon of refined product, varying according to product and over time. (The allocation of banked costs to particular products is misleading because the regulations allow some transferring of banked costs among products as described above.)

The 1973 crude oil price increases produced immediate and persistent positive banked costs. This is direct evidence of the nonbindingness of the controls. We therefore believe that U.S. petroleum product prices are set, not by the FEA, but by world market conditions, and that one could conceptually show this equality, once proper adjustments had been made for transportation costs, tariffs, true exchange rates, and other factors. We feel that such an analysis is too hazardous to attempt, given the limitations of available data, and we have chosen not to undertake the task.[6] An alternative empirical verification of our view of the world is presented next.

STATISTICAL ANALYSIS OF BANKED COSTS

We undertake an empirical analysis of banked costs to test our

Table 1

BANKED COSTS: CENTS PER GALLON OF PRODUCT SOLD BY MONTH

Date	Product						
	Distillates		Gasoline		Other		Total
1973							
November		(0.1)[a]		(1.2)[a]		(-0.2)[a]	
December		(1.9)		(1.6)		(0.6)	
1974							
January	2.8[b]	(2.1)	1.5[b]	(1.2)	0.5[b]	(0.4)	1.4[b]
February	4.5	(3.9)	1.4	(1.2)	2.2	(1.6)	2.4
March	5.8	(4.7)	1.3	(0.6)	3.3	(5.0)	3.0
April	7.3	(7.0)	3.1	(2.6)	5.0	(6.3)	4.6
May	9.9	(9.0)	3.6	(3.0)	6.4	(8.3)	5.7
June	12.8	(12.4)	4.4	(4.7)	8.6	(10.7)	7.8
July	14.4	(12.6)	4.4	(3.9)	8.5	(10.3)	7.6
August	14.3	(13.7)	4.6	(4.2)	8.6	(11.0)	7.9
September	16.5	(14.0)	6.3	(6.6)	8.4	(10.4)	8.7
October	9.5	(8.1)	5.9	(4.5)	6.7	(8.3)	6.8
November	7.2	(7.4)	6.8	(6.1)	7.3	(9.8)	7.1
December	5.1	(5.5)	5.9	(5.3)	6.4	(8.5)	5.8
1975							
January	6.0	(5.6)	6.5	(6.7)	8.8	(10.0)	7.0
February	7.1	(7.6)	6.4	(7.4)	11.0	(12.4)	7.3
March	8.0	(7.8)	6.7	(7.1)	13.5	(16.0)	9.7
April	9.1		6.7		12.1		9.3
May	11.4		5.0		12.3		8.9
June	11.7		3.5		11.7		8.0
July	10.3		2.9		8.1		6.1
August	12.0		4.6		8.3		7.2
September	15.0		4.6		9.0		7.9
October	11.8		3.4		9.1		7.2
November	15.6		4.0		10.9		8.9
December	11.0		2.9		10.4		7.7

[a]Numbers in parentheses represent preliminary unpublished FEA data on banked costs *for the entire* industry (letter to authors, November 13, 1975).

[b]Calculated from published FEA data on banked costs for 30 largest refiners. Average market share of those firms is 86 percent. These calculations assume total industry sales are proportionate to this for each product. Quantity and banked cost data from FEA (1976).

theory of product prices. We study total banked costs because the regulations allow arbitrary transfers of banked costs across product categories. Using the FEA price ceiling defined in Eq. (4.1), the time path of the stock and flow of banked costs per unit of product sold can be described by the following equations:

$$\text{(stock equation)} \quad g_t = P_c - P_t = K \cdot a \cdot w_t^a + m_t \cdot P_t + g_{t-1} - P_t \qquad (4.4a)$$

$$\text{(flow equation)} \quad F_t = g_t - g_{t-1} = K \cdot a \cdot w_t^a + (m_t - 1)P_t \qquad (4.4b)$$

where g_t is the per gallon stock of banked costs at time t.

F_t is the per gallon flow of banked costs at time t.

P_c is the FEA allowable increase above base price in product price at time t.

K is the percentage of true economic cost increases that is allowable in the definition of the FEA price ceiling, which we earlier estimated to be .63.[4]

a is the input/output coefficient for crude oil.

w_t^a is the difference between the world crude oil price at time t and the base period.

m_t is the ratio of monthly base-period product imports to the volume of domestic refining at time t.

P_t is the difference between the equilibrium product price at time t and the base period.

The price controls themselves are binding only when the stock of banked costs is zero, since refiners will always have the option of depleting their stock of banked costs whenever the flow of banked costs become negative.[7] Using the theory of product prices developed in Sec. III, we can derive and test a variety of propositions concerning the determinants of banked costs.

Consider the impact of an increase in the world price of crude

oil. The change in the flow of banked costs can be calculated by taking the differential of Eq. (4.4b) with respect to w_t^a. This yields:

$$dF_t = \left\{ K \cdot a + (m_t - 1) \frac{\partial P_t}{\partial w_t^a} \right\} dw_t^a \tag{4.5}$$

where

$$\frac{\partial P_t}{\partial w_t^a} = a + b \frac{\partial w_t^b}{\partial w_t^a}$$

Substituting from Eq. (3.5a) and Eq. (3.5b) for $\partial w_t^b / \partial w_t^a$, and recalling that $a \simeq 1$ for petroleum refining,

$$\frac{dF_t}{dw_t^a} = (K - 1) + \left\{ \frac{-\alpha_B(\sigma + \eta)}{\varepsilon_B + \alpha_A\sigma - \alpha_B\eta} \right\} + m_t \left\{ 1 + \frac{\alpha_B(\sigma + \eta)}{\varepsilon_B + \alpha_A\sigma - \alpha_B\eta} \right\} \tag{4.6}$$

or

$$\frac{dF_t}{dw_t^a} = (K - 1) + (1 - m_t) \left\{ \frac{-\alpha_B(\sigma + \eta)}{\varepsilon_B + \alpha_A\sigma - \alpha_B\eta} \right\} + m_t \tag{4.7}$$

The term in braces in Eq. (4.7) is signed opposite to $(\sigma + \eta)$ and represents the ratio, λ, of crude oil cost increases that are borne by owners of factor B (specific to refining). Since that ratio must be bounded by (0,1), Eq. (4.7) is bounded by $(K + m_t - 1, K)$. In a regression of the flow of banked costs, the estimated coefficient for the world crude price variable, β_p, can be used to estimate λ:

$$\hat{\lambda} = \frac{\hat{\beta}_p - (K - 1) - m_t}{(1 - m_t)} \tag{4.8}$$

Hypotheses on other variables are easier to derive. Changes in the crude oil tariff from the base period are allowable costs in the price formula but would not affect world product prices unless the United States had substantial market power (a case we analyze in Sec. VIII). Hence the coefficient on crude oil tariff differentials (above base level) must be algebraically larger than the coefficient on world crude oil price differentials.

Earlier comments about the "tendency for the price controls to become binding (nonbinding)" can now be stated in empirically testable fashion. Increases in the level of world economic activity from the base period should reduce the flow of banked costs, as should increases in the general U.S. price level relative to the base period. The level of monthly base-period product imports relative to total current refining is included to account for direct product price increases on imported products (the term B_i^t/q_i^t in Eq. (4.1)). The coefficient should be an estimate of the average world product price increase over the sample period.[8]

An increase in the product tariff from the base period should have a negative coefficient on banked cost flows. The increased tariff drives up the domestic price on products but only a fraction enters the price formula (that applied to the base-period product import levels). Also, the refined product trade-weighted exchange rate between the United States and its trading partners should enter the regression with a positive coefficient. Revaluation of the dollar drives down U.S. product prices because world imports become lower priced.[9] Finally, we include the entitlement subsidy as an explanatory variable to test for the presence of U.S. power in world product markets. The results of this test are interpreted in Sec. VIII.

Two regressions were estimated using monthly data from January 1974 through December 1975. The dependent variable is the aggregate flow of banked cost per gallon of product for the thirty largest refiners in the United States (who collectively account for 86 percent of production). All expenditures or price-related variables have been placed in real terms by using the standard U.S.

price index (*Federal Reserve Bulletin*, 1976). The data sources and summary statistics are presented more fully in the appendix.

Equation 1 in Table 2 presents the full model as specified by the theory. While the variables all have the theoretically predicted signs, the precision is low. Both the entitlement and product tariff coefficients are of the correct sign, but of small magnitudes and low t-statistics. Analysis of interdependence among explanatory variables showed multicollinearity in our data set. We reestimated the equation excluding the entitlement and product tariff variables. The remaining coefficients (Eq. (2)) were virtually unchanged, but the precision of the estimates was improved.

All but one of our hypotheses are supported by these estimates.[10] The coefficient on the crude oil price variable indicates that approximately 55 percent of crude oil price increases are borne by owners of capital specific to that industry.[11] As hypothesized, the crude oil tariff coefficient is larger than the coefficient on crude oil price, although the difference is insignificant (t = .43). The level of economic activity is negatively associated with banked costs, although the coefficient has a large standard error relative to the estimated value. General inflation also drives down banked costs, as predicted by the theory. Base-period import levels are positively associated with banked costs. The coefficient on imported products is 13¢ per gallon and is an estimate of the average world product price increase since May 15, 1973. (For the same period, for motor gasoline in the United States, the average increase was 14.25¢.)[12]

To summarize, we have shown under what conditions one would theoretically expect price controls of the type administered by the FEA to be nonbinding. We have presented evidence that these controls are indeed nonbinding for refined products. Using the implications from this analysis, we have studied flows in industry banked costs, month by month over a two-year time span to further test the predictions from our model. The results from this analysis provide some measure of statistical support.

Table 2

REGRESSION ESTIMATE OF FLOW OF BANKED COSTS PER UNIT OF SALES FOR THE U.S. REFINING INDUSTRY, TOP 30 FIRMS

Independent Variable	Equation 1 Coefficient (t-statistic)	Equation 2 Coefficient (t-statistic)
Constant term	-.0440 (1.11)	-.0452 (1.29)
Real crude oil price (tariff exclusive)	(.289) (1.30)	.287 (1.38)
Real crude oil tariff	.358 (1.09)	.366 (1.23)
Real income for selected OECD[a] countries	-.000515 (.45)	-.000581 (-.75)
U.S. general price level	-.0834 (.98)	-.0802 (1.78)
Base-period product import quantities relative to current product production	.122 (1.52)	.125 (1.83)
Real product tariff	-.0220 (.005)	--
Real value of entitlement	.0298 (.09)	--
R^2	.330	.330
F (degrees of freedom) (probability of F)	F(7,16) = 1.13 (P = .394)	F(5,18) = 1.772 (P = .170)
Durbin-Watson statistic	2.34	2.31

[a]Organization for Economic Cooperation and Development.

FOOTNOTES

[1]Base prices of low distillates were allowed to be increased by 2¢ per gallon. Base prices of petrochemical feedstocks were allowed to be increased to 115 percent of the original base. Home heating oil and diesel fuel base prices were allowed to increase by the product of 2¢ × (May 15, 1973, gallons of distillate) ÷ (May 15, 1973, gallons of gasoline), which produced an average allowable increase of about 1¢ per gallon (CFR Sec. 212.84).

[2]We have used the same notation as found in *Federal Register*, Sec. 212.83, 1975.

[3]For input/output data, see FEA (1976). Equation (3.8a) shows that the input-output coefficient is independent of factor prices only if the elasticity of substitution σ is zero.

[4]The formula defines the average cost of crude oil to be $\bar{w} = S_c w_c + (1 - S_c)w_w$ where w_c and w_w are the controlled and uncontrolled (world) prices, respectively, and S_c is the fraction of total crude oil purchases accounted for by controlled oil. Differentiating, and allowing S_c to change, yields

$$(*) \quad \frac{d\bar{w}}{dw_w} = \frac{dS_c}{dw_w} w_c + (1 - S_c) - \frac{dS_c}{dw_w} w_w$$

$$= (1 - S_c) - (w_w - w_c) \frac{dS_c}{dw_w} = (1 - S_c) \cdot \left(1 + S_c \frac{(w_w - w_c)}{w_w} \eta_w\right)$$

where η_w is the elasticity of demand for uncontrolled oil.

Expression (*) is positive if $\eta_w > -w_w/S_c(w_w - w_c)$. Approximating w_w, w_c, and S_c by the 1975 values ($w_w \simeq \$14$, $w_c \simeq \$5.25$, and $S_c \simeq .3$), expression (*) is positive if $\eta_w > -5.33$, a condition that is satisfied because the elasticity of demand for crude oil is approximately -.5 (Kennedy, 1974).

Evaluating expression (*) at $\eta_w = -.5$, $w_c = \$5.25$, $w_w = \$14$, and $S_c = .3$,

$$\frac{d\bar{w}}{dw_w} = .63$$

Without product substitution ($\eta_w = 0$), $\frac{d\bar{w}}{dw_w} = (1 - S_c) = .7$.

[5]In Sec. VIII, we generalize this result for the case where the United States has market power.

[6]The comparison must use spot, not long-term, contract prices. If spot prices are expected to increase (decrease) in the future, long-term contract prices will be higher (lower) than the current spot price. The data must also distinguish between posted and transactions prices, as the discrepancy is often important (Stigler and Kendahl, 1970).

The price data must represent arms-length transactions between separate companies, rather than accounting prices for transactions between refining and importing subsidiaries of multinational oil firms.

The price comparison must control for differences in nonprice terms for the domestic and foreign contracts, including terms of credit, promptness, and reliability of delivery.

The comparisons must also consider tariff and nontariff barriers to trade. Import and export taxes and controls, required membership in commodities trading unions, and the like, all generate differences between U.S. and foreign prices that exceed transportation cost of the product.

Finally, the exchange rate used to convert foreign prices into U.S. dollar prices must reflect the true relative values of the currencies. For countries with a floating free exchange rate, such as Canada and the Netherlands, the official rate is the correct choice. For countries with exchange controls, such as Italy or

Venezuela, the choice is less straightforward, since the official rates will often diverge markedly from free-market rates (Pick's, 1976).

Actual price comparison may likely be unable to control for all of these elements. For those willing to make the attempt (among whom we do not number ourselves), a simple test of accuracy is available: The computed landed price of the product, in U.S. dollars, should be identical for products from every trading partner. This test is independent of one's beliefs about the equality of U.S. and world prices, but merely assumes that importers will always buy from the cheapest foreign source. Persistent landed price differentials suggest errors in methodology or data.

[7]If the firm thought it would use all its banked costs, it would be to its advantage to deplete them as fast as possible. Otherwise it would forgo the interest on the additional revenue if it saved the banked costs for later months.

[8]This latter coefficient also provides an interesting test about the equality of world and U.S. product prices--the price increase in world markets that is estimated by our equation, in the absence of binding controls, should match the average (over time) price increase in domestic refined product prices.

[9]We found that the actual amount of variation in the exchange rates (using black market rates wherever appropriate, taken from Pick's (1976)) had almost no variation, and we excluded it from the regression analysis.

[10]That we estimated no significant effect of the product tariff on banked costs is contrary to our theory.

[11]See Eq. (4.8), recalling that we estimate (K - 1) to be .37, and noting that the mean of m_t is .25 in our sample (see the appendix).

[12]From FEA (1976), p. 56, using average purchase price to dealers.

V. THE ENTITLEMENT PROGRAM

A BEHAVIORAL MODEL

The Old Oil allocation program, as described in Sec. VI, successfully transferred economic rent from crude oil producers to domestic refiners. The entitlement program attempts to change the distribution of that transfer so that refiners receive rent proportional to their use of crude oil, rather than to the volume of Old Oil. We will show that this program leads refiners to expand domestic production. In this section we confine the discussion to the case where the United States is a price-taker in world markets for crude oil and refined products.

The entitlement program implements the use of tickets for a rationed commodity. Possession of a ticket (entitlement) is required to use each unit of the controlled commodity (Old Oil). If tickets were freely transferable, then the price of the ticket would equal the economic rent enjoyed by the users of the rationed commodity. The initial distribution of tickets among refiners would determine how the rent was distributed.

There is an important element of the entitlement program that requires extension beyond the usual analysis of ration tickets. While the rent transferred to the refining industry is fixed, the share received by an individual refiner depends on his behavior. The FEA distributes entitlements to refiners in proportion to their total use of crude oil. An individual refiner can increase his share of the rent transfer by expanding his use of crude oil. The entitlement program offers a per-unit subsidy equal to the value of an entitlement, P_E, multiplied by the national Old Oil ratio, F.

All refiners cannot expand their use of crude oil and together receive additional entitlements; if they tried, the Old Oil fraction would fall. A simple strategic game summarizes this conflict. To simplify, we assume that each refiner is sufficiently small that his decision about expansion does not influence the decisions of other

refiners. We also assume that the individual refiner believes that all other refiners face the same problem but not necessarily that they reach the same decision.

Table 3 presents the payoff matrix for an individual refiner and the total industry. There are four possible states of the world, defined by whether the individual refiner and other refiners respond to the subsidy. The matrix demonstrates conflict between the interest of the individual refiner and the industry as a whole. As shown below, the industry as a whole would be better off if no refiner responded to the subsidy, but individual refiners have an incentive to respond. Their decision does not depend upon their expectations about the decisions of other refiners. (This is an analogous problem to the cheater in a cartel.)

Table 3

THE PAYOFF MATRIX FOR AN INDIVIDUAL REFINER AND THE ENTIRE INDUSTRY[a]

	Other Refiners	
Individual Refiner	Respond to Subsidy	Do not Respond
Responds to subsidy	Refiner: $\frac{P_E F \Delta q}{2} + P_E q \Delta F < 0$ Industry: $\frac{-P_E F \Delta Q}{2} < 0$	Refiner: $\frac{P_E F \Delta q}{2} > 0$ Industry: $\frac{-P_E F \Delta q}{2} < 0$
Does not respond	Refiner: $P_E q \Delta F < 0$ Industry: $\frac{-P_E F \Delta Q}{2} < 0$	Refiner: 0 Industry: 0

[a]See text for interpretation of table, and definition of variables.

Consider the decision of the individual refiner when the industry does not respond to the subsidy. The refiner expands output until the marginal cost of production equals the sum of the product price and the size of the subsidy. Let Δq denote the optimal increase in production, F denote the Old Oil fraction, and P_E the entitlement price. The refiner's increase in profits is equal to the value of the additional entitlements received, $P_E F\Delta q$, minus the amount that production costs exceed the sales revenue from the additional use of crude oil, $-(1/2)P_E F\Delta q$.[1] The increase in profits is $1/2P_E F\Delta q$. For the industry as a whole, profits fall by $1/2P_E F\Delta q$ because the individual refiner's increased entitlement revenue simply represents an income transfer within the industry. Alternatively, if the individual refiner also did not respond to the apparent subsidy, then the profits of that refiner and the refining industry remain unchanged. Consequently, if the individual refiner believes that the other refiners will not respond to the subsidy, his profitable strategy is to expand his use of crude oil.

Now consider the decision of the refiner when other refiners do respond to the subsidy. The expansion by the industry as a whole drives down the Old Oil ratio, F, because the amount of Old Oil is fixed to the industry. If the individual refiner does not respond to the subsidy, he loses profits equal to his initial use of crude oil, q, multiplied by the decline in the Old Oil fraction, ΔF. The decrease in his profits is $P_E q\Delta F$. On the other hand, if the refiner also expands his production, then he can partially offset his loss.[2] He loses less, given an industry response to the subsidy, by expanding his own use of crude oil.

Therefore, the decision of the refiner to respond to the subsidy is independent of the decisions of other refiners, and hence of his beliefs about the probability that other refiners respond. Consequently, our modeling of the strategic game does not include a role for expectations about the behavior of competitors.

In the appendix, we present a noncooperative game for analyzing the industry response to the entitlement program. We also describe there how the sale of entitlements transfers economic rent from the

buyers of entitlements to the sellers of entitlements. The amount of rent transferred equals the value of an entitlement multiplied by the volume of entitlements sold. The program has a similar impact on crude oil use and refining as a per-unit subsidy on uncontrolled crude oil. Table 4 presents the monthly per-unit subsidy since the introduction of the entitlement program until January 1976.[3]

Table 4

PER-UNIT SUBSIDY ON UNCONTROLLED OIL

Date	$/Barrel	¢/gallon
1974		
November	2.05	4.9
December	2.00	4.8
1975		
January	2.11	5.0
February	2.52	6.0
March	2.62	6.2
April	2.85	6.8
May	2.83	6.7
June	2.82	6.7
July	2.87	6.8
August	2.92	7.0
September	2.95	7.0
October	3.07	7.3
November	3.07	7.3
December	3.10	7.4
1976		
January	2.50	6.0

SOURCE: *Federal Register*, Vols. 40 and 41, various issues, for data on the price of entitlements and the national Old Oil fraction.

It would be inaccurate, however, to view the entitlement program as being identical in all respects to a per-unit subsidy. First, derivation in the appendix shows that a monopolistic (or cooperating) refining industry would not respond to the entitlement subsidy. (In contrast, competitive, cooperative, and monopolistic industries all

would change their outputs when offered a per-unit subsidy on an input.) Second, the industry is worse off after the introduction of the entitlement program. (In contrast, an industry is expected to gain from per-unit subsidization of the use of an input.)

Thus far we have assumed that entitlements are transferred among refiners at a price determined by a free market. Actually, FEA fixes that price to equal the difference between the national average prices for uncontrolled and controlled oil. In the absence of price differentials for crude oil, the FEA price would mimic the market-clearing price for entitlements. However, price differentials for crude oil exist to reflect differences in quality and geographic location. The value of entitlements would depend upon the specific type of controlled crude oil purchased. Entitlements would be equally valuable for the purchase of any quality of crude oil, only if crude oil price differentials had not changed since 1972. Otherwise, entitlements would be more valuable for purchasing qualities of crude oil whose uncontrolled prices increased by the largest absolute amount.[4] The remaining discussion does not consider the economic implications of this feature of the program.

ECONOMIC EFFECTS

Under the assumption that the United States is a price-taker in world crude oil and refined products markets, the economic effects of the entitlement program are confined to U.S. trade flows and the profitability of domestic refining. The subsidy would expand domestic production of refined products, would reduce imports of refined products, would increase imports of crude oil, but would have no impact on product and crude oil prices or on domestic consumption of refined products. These effects are depicted in Fig. 2. The pre-entitlement curves are subscripted with "0," and the post-entitlement curves are subscripted with "E." Tables 5 and 6 offer some evidence supporting this interpretation.

Table 5 shows that gasoline and heating oil prices did not decline after the introduction of the entitlement program. Prices remained firm despite the crude oil subsidy of approximately 5¢ per

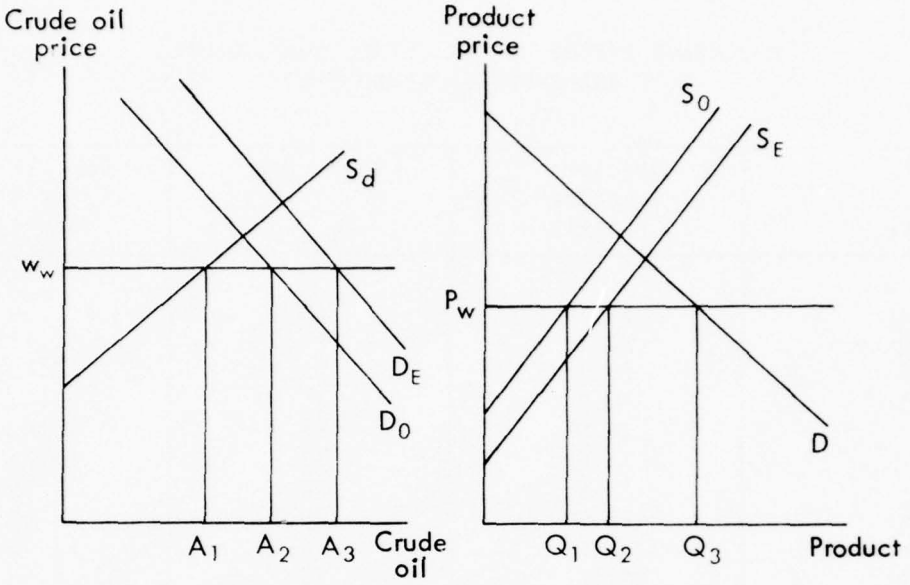


Fig. 2 — The impact of the entitlement program on U.S. crude oil and refined products markets

gallon during the early months of the program (see Table 4). Our analysis of banked cost flows shows that approximately 55 percent of factor price changes are borne by owners of factors specific to refining. Thus a 5¢ per gallon subsidy, in the absence of world trade, should have reduced domestic prices by 2.3¢ per gallon. Of course, this simple comparison of pre- and post-entitlement program months neglects other phenomena that may have offset the downward pressure on U.S. product prices.

Other events, however, could not have completely obscured any impact of the entitlement program on U.S. product prices. The U.S. monthly rate of inflation was well below 1 percent during late 1974 and all of 1975 (Federal Reserve Board, 1976). U.S. real income actually declined during the fourth quarter of 1974 and the first quarter of 1975 (Organization for Economic Cooperation and Development, 1976). Thus, changes in economic activity should have reinforced the downward pressure on product prices. Meanwhile, the price of foreign crude oil increased by about 1¢ per gallon from

Table 5

WHOLESALE PRICES FOR GASOLINE, HEATING OIL, AND IMPORTED CRUDE OIL

Date	Regular Gasoline[a] (¢/gal)	Heating Oil[a] (¢/gal)	Imported Crude Oil[b] ($/bbl)
1974			
January	25.2	23.4	9.59
February	27.5	25.4	12.45
March	29.2	25.9	12.73
April	30.5	25.9	12.72
May	31.9	26.8	13.02
June	32.6	27.5	13.06
July	32.8	28.1	12.75
August	32.9	28.1	12.68
September	32.6	28.7	12.53
October	31.2	28.9	12.44
November[c]	31.0	29.1	12.53
December	31.1	28.5	12.82
1975			
January	31.2	29.1	12.77
February	31.3	28.7	13.05[d]
March	31.6	28.4	13.28
April	32.7	29.3	13.26
May	33.8	30.0	13.27
June	35.3	30.3	14.15[e]
July	38.1	30.6	14.03
August	38.6	31.2	14.25
September	38.9	31.0	14.04
October	38.5	31.8	14.66
November	38.0	32.1	15.04
December	37.7	32.4	14.81

[a]Average dealer purchase price (net of taxes), FEA (1976).

[b]Average imported crude prices, inclusive of license fees, FEA (1976).

[c]Entitlement program began in November 1974.

[d]Includes $1 per barrel license fee for February through May 1975.

[e]Includes $2 per barrel license fee for June through December 1975.

Table 6

TOTAL REFINED PETROLEUM PRODUCTS
(In thousands of barrels per day)

Date	Domestic Demand[a]	Imports[a]
1974		
January	17,286	2,989
February	17,366	2,968
March	16,104	2,812
April	15,929	2,713
May	15,726	2,586
June	16,117	2,435
July	16,349	2,445
August	16,550	2,438
September	16,024	2,255
October	17,050	2,366
November	17,351	2,840
December	18,013	2,798
1975		
January	17,983 (1.04)	2,811 (.94)
February	17,248 (.99)	2,348 (.79)
March	16,316 (1.01)	2,074 (.74)
April	16,041 (1.01)	1,655 (.61)
May	15,118 (.96)	1,690 (.65)
June	15,611 (.97)	1,502 (.62)
July	15,762 (.96)	1,789 (.73)
August	15,767 (.95)	1,681 (.69)
September	15,769 (.98)	2,116 (.94)
October	16,344 (.96)	1,907 (.81)
November	15,721 (.91)	1,739 (.61)
December	17,987 (1.00)	1,751 (.63)
Average[b]	.98	.73
Standard Deviation	.033	.117

SOURCE: FEA (1976).

[a]The ratios of 1975 to 1974 monthly domestic demand and imports are reported in parentheses in the appropriate columns.

[b]T-statistic on difference of means = 2.21. The covariance between the monthly domestic demand and import ratios is .002.

October 1974 to February 1975 and would have led to an increase in product prices of approximately 0.45¢ per gallon. Thus, the large subsidy from the entitlement program should have dominated any conflicting pressures originating from U.S. and world economic decline, inflation, and the changes in price of crude oil.

The subsidy offered by the entitlement program should still have dominated the increased crude oil tariff after February 1975. The $2 per barrel tariff could have increased the landed price of crude oil by at most 4.8¢ per gallon. By this time, the subsidy had increased to approximately 7¢ per gallon. Consequently, the presence of other phenomena does not appear to explain why U.S. product prices did not decline after the introduction of the entitlement program. A high product import supply elasticity does offer an interpretation.

Table 6 shows that refined product imports did decline after the introduction of the entitlement program. Monthly volumes of product imports were from 5 to 40 percent below their 1974 levels, while monthly domestic demand for products remained virtually at 1974 levels. This evidence suggests that the entitlement program created an expansion in domestic refining that was offset by a decline in imports of refined products.

Chapel (1976) has estimated the impact of the entitlement program on U.S. trade in refined products. Using monthly data from January 1973 to February 1976, he estimated an equation stating that product imports were a linear function of the ratio of domestic consumption to refining capacity and of a dummy variable signifying the presence of the entitlement program. Table 7 presents his results. The decline in product imports illustrates that refiners and importers respond to the economic incentives provided by the entitlement program. Another inference is that not all imports of the listed products represent long-term contracts that could not be adjusted in response to the incentive to import. Note that a product's estimated percentage decline in import volume is not related to the fraction of domestic consumption that is imported, as is consistent with standard analysis of world traded products.[5]

Table 7

ESTIMATED IMPACT OF THE ENTITLEMENT PROGRAM ON PRODUCT IMPORTS

Product	Percentage of Domestic Consumption Imported	Average Imports[a]	Change Due to Entitlements[a] (t-ratio)	Estimated Reduction as Percentage of Imports
Total refined products	14.8	2493	-389 (4.56)	-16.0
Gasoline	2.6	170	-25 (1.26)	-15.0
Jet fuel	16.2	164	-38 (2.24)	-23.0
Distillate fuel oil	9.1	275	-14 (0.41)	-5.0
Residual fuel oil	58.2	1536	-221 (4.38)	-14.0

SOURCE: Chapel (1976), Table 2.

[a]1000 bbl/day.

The entitlement program also reduced the profits in domestic refining and transferred economic rent among domestic refiners. As discussed above, the decline in industry profitability depends upon the percentage increase in industry output in response to the entitlement program. Table 8 presents estimates of the decline in profitability, based upon the results from Chapel's analysis of refined product imports. In addition to the "mean" estimate of the reduction in product imports, we provide "high" and "low" estimates defined as the mean $\pm$ two standard deviations from the estimated coefficient.[6] The resulting estimates of \$0.2 to \$0.3 billion of reduced profitability are substantially smaller than the \$1.5 billion of economic rent transferred within the industry by the entitlement program.[7]

The entitlement program thus offers evidence on a remarkable

Table 8

ESTIMATES OF THE DECLINE IN REFINING INDUSTRY PROFITABILITY IN 1975 DUE TO THE ENTITLEMENT PROGRAM

Assumption About Increased Output of Domestic Refining	Reduction in Industry Profits ($ billions)
High (= mean + 2σ)	0.28
Mean	0.24
Low (= mean - 2σ)	0.18

SOURCE: Chapel (1976). Evaluation of formula for reduced industry profits. The formula was evaluated using the 1975 volume of Old Oil production, the average value of an entitlement in 1975, and the 1975 volume of crude oil inputs to domestic refining. Estimates of the increase in domestic refining output were taken from Chapel's analysis, as discussed in the text.

array of economic questions concerning the U.S. refining industry and its position in world markets. First, the industry response to the entitlement program was as predicted for a profit-maximizing industry. Second, the response is inconsistent with a monopolized or cooperating industry. Third, the responsiveness of import demands demonstrates that a significant fraction of product imports is subject to change as incentives are altered. Finally, because prices did not decline, the inference may be drawn that the United States has no significant market power in world refined product markets, at least over the range of product imports accounted for by current economic conditions.

FOOTNOTES

[1]This formula linearly approximates the producer surplus forgone by extending production beyond the level where the marginal resource

cost of production equals the market price. It is optimal for the individual refiner to increase his production because the forgone producer surplus is less than the value of the additional entitlements.

[2]Since

$$F = \frac{Q_o}{Q_o + Q_n}, \quad \frac{\partial F}{\partial Q_n} = \frac{-Q_o}{(Q_o + Q_n)^2} = -F/Q$$

Hence

$$\Delta F = \frac{\partial F}{\partial Q} \Delta Q = -F \frac{\Delta Q}{Q}$$

Substituting in the expression for the net gain of the individual refiner (from Table 3) we have

$$P_E F \left\{ \frac{\Delta q}{2} - \frac{q}{Q} \Delta Q \right\} = P_E F \Delta q \left\{ .5 - \frac{q}{Q} \frac{\Delta Q}{\Delta q} \right\} \lessgtr 0 \text{ as } \frac{\Delta q/q}{\Delta Q/Q} \lessgtr 2$$

The ratio of the percentage increase in the firm's use of crude oil to the percentage increase in the industry's use of crude oil is simply the ratio of the firm's demand elasticity for crude oil to the industry's demand elasticity for crude oil. Any refiner earns positive profits by responding to the subsidy if his demand for crude oil is at least twice as elastic as the industry's. All other refiners lose profits, but they lose less than if they did not respond. Since the industry crude oil demand elasticity is a weighted average of all firm's crude oil demand elasticities, only a minority of firms would earn positive profits when everyone responds to the subsidy, although every refiner would have the incentive to respond.

[3]The importance of the entitlement subsidy is slightly mitigated by the exemption of some refiners (whose crude oil use represented approximately 5 percent of total Old Oil use in 1975) from the entitlement program. For these refiners, there is no change in the marginal cost of oil, or in incentives to refine. The estimated

fraction of Old Oil use was obtained by comparing the number of entitlements issued in 1975 (*Federal Register*, various issues) with U.S. Old Oil production. The latter data were estimated by multiplying the U.S. Old Oil ratio by total domestic production (FEA, 1976).

[4]Let w_u^i and w_c^i be the uncontrolled and controlled prices for the ith quality of crude oil. The value of an entitlement in the purchase of controlled crude oil of quality i is $P_E^i = w_u^i - w_c^i$. Thus, $P_E^i \gtrless w_E^j$, as $(w_u^i - w_c^i) \gtrless (w_u^j - w_c^j)$.

[5]Chapel also attempted to estimate the program's effects on crude oil imports, but the specification he chose is incorrect. Although he estimated the anticipated positive effect, we do not feel that the equation provides good evidence on the question at hand.

[6]Under the assumption that the United States has no market power in world crude oil and refined product markets, the reduction in product imports equals the increase in domestic refining output.

[7]The estimate of the economic rent transferred was obtained by multiplying the volume of entitlements sold in 1975 by the average value of an entitlement. Data obtained from *Federal Register*, various issues.

VI. THE ALLOCATION PROGRAM

The allocation program defined a mechanism whereby Old Oil is allocated among potential buyers according to monthly deliveries during 1972.[1] The importance of establishing property rights to controlled oil is illustrated by experience before the allocation program. Before assignment of property rights to Old Oil, buyers of crude oil would compete for the rights to Old Oil. Tie-in sales would be expected, wherein the alleged price of uncontrolled oil would rise until the average price of all oil purchased in a given transaction equalled the landed price of foreign crude oil of comparable quality. Such tie-in sales would enable crude oil producers to retain the economic rent on their Old Oil, despite the intention of the price controls. In fact, tie-in sales were observed prior to the allocation program, as discussed in Sec. II.

By precluding such competitive bidding by potential buyers, the allocation program enabled the successful transfer of economic rent from crude oil producers to domestic refiners. The impact of this transfer on firm profitability depends upon the degree of vertical integration. Independent refiners receive economic rent equal to their allocation of Old Oil multiplied by the difference between the uncontrolled and controlled price. Fully vertically integrated firms receive a transfer from their producing subsidiary to their refining subsidiary, but the firm's overall profitability remains unchanged. Thus, estimation of the rent transfer from crude oil producers requires information about the fraction of crude oil production used by subsidiary refineries during the base period of the controls.

Existing data sources provide only estimates of company self-sufficiency, the ratio of domestic crude oil production to domestic refining output. The ratio understates the fraction of each firm's domestic crude oil production used by its domestic refining subsidiaries, because a portion of domestic refining output derives from imported crude oil. That some refiners exchanged oil to minimize

transportation costs poses no particular problem in interpreting the data, because the exchanged oil simultaneously becomes an obligation to sell and a right to purchase Old Oil.

Data on company self-sufficiency (Table 9) provide an approximate idea about the extent and variability of vertical integration in the domestic petroleum industry. Since the allocation scheme is based upon 1972 transactions, the table reporting 1971 self-sufficiency gives an approximate representation of the extent of vertical integration for the selected firms during the base period. All these companies are not entirely self-sufficient in crude oil, so that they benefit to some extent from the allocation scheme. However, the extent of the gain is relatively less for the more integrated firms, such as Exxon, Gulf, and Texaco, than for the less integrated firms, such as Phillips, Standard Oil of Indiana, and Mobil.

Table 9

CRUDE OIL SELF-SUFFICIENCY FOR FOURTEEN U.S. COMPANIES, 1971

Company	Ratio of Crude Production to Refinery Output
Marathon	0.900
Cities Service	0.851
Continental	0.850
Union	0.813
Exxon	0.806
Texaco	0.803
Gulf	0.776
Sun	0.726
Standard Oil of California	0.659
Shell	0.651
Arco	0.628
Mobil	0.604
Standard Oil of Indiana	0.586
Phillips	0.533

SOURCE: First National City Bank (1973).

We have not been able, however, to obtain complete data on firm-specific production (by crude oil producers) and use (by refiners) of Old Oil, and therefore we are unable to compute exactly the total value of economic rents transferred by the allocation program. An upper estimate for the industry ignores vertical integration; in this case the transfer in 1975 is estimated to be $8 billion. A lower estimate considers vertical integration by assuming that all vertically integrated firms are self-sufficient, so that rent transfers occur only on Old Oil produced by independent crude oil producers. Since independent crude oil producers account for approximately one-third of U.S. domestic production, the allocation program transferred at most one-third of the previous estimate, or $2.7 billion in 1975.[2]

FOOTNOTES

[1]As Old Oil production declines, the reductions are prorated according to initial quantities delivered to each refiner.

[2]Duchesneau (1975), Table 2-14, shows that the major and integrated refiners produced 67 percent of U.S. crude oil in 1970. Thus the one-third share for independent producers is a rough estimate but sufficiently precise to illustrate the importance of vertical integration in assessing profit transfers.

VII. DOMESTIC OIL PRODUCTION

While the controls on product prices are not binding under current conditions, there are binding price ceilings on crude oil production. Under the 1973 EPAA, a ceiling price was placed on the first A_o barrels of production from each field in operation in May 1973, where A_o was the month-by-month production from each field during 1972. The May 15, 1973, posted price (with $1.35 added later) became the control price w_c. Under the usual analysis of price controls, one would predict a reduction in U.S. crude oil production, and many observers have used this model to account for the declining U.S. production after 1973. If the United States possessed power in world markets, this decline in production would have raised world oil prices, and hence U.S. product prices, either through its effect on total world crude oil production, or on OPEC pricing policy, or both. In this section, we discuss several features of the FEA regulations that confound both the theoretical analysis and the interpretation of U.S. crude oil production data over time.

THE THEORETICAL CASE: 1973 EPAA

The Released Oil and New Oil features render ambiguous the theoretical impact of the 1973 EPAA regulations. For controlled properties, these regulations allowed one barrel of Old Oil (up to production of A_o) to be sold at uncontrolled prices--for each barrel of production above A_o, with the excess production above A_o also uncontrolled. For example, if a property produced 100 barrels in the base period, but produced 140 barrels in the current period, then that property would be considered to have produced 40 barrels of New Oil, 40 barrels of Released Oil, and 60 barrels of Old Oil. Thus, producers faced a discontinuous price line. For quantities of production below A_o, the price is the controlled price, w_c. For quantities between A_o and $2 \cdot A_o$, the price line (marginal revenue) is $2 \cdot w_w - w_c$, the sum of the world price, w_w, for the additional barrel, plus the "bonus" differential $(w_w - w_c)$ for a barrel of

Released Oil. For production in excess of $2 \cdot A_o$, the price line is the world price, w_w.

We analyze below the decisions of various producers, all of whom are assumed to have had base-period productions of A_o. A brief excursion into petroleum technology is required to understand how the alternative positions shown in Fig. 3 might be reached. First, one anticipates a gradual upward shifting of the marginal cost curve for a particular property over time because oil is being extracted from a finite reservoir. We shall call this phenomenon "natural retrogression" of a producing property. Similarly, one anticipates that at any given time, extraction costs will rise with the rate of extraction, leading to generally upward sloping supply curves. The supply price elasticity will also be smaller in the short run, because supply can only be increased by additions of more capital--pumps, secondary and tertiary (hot water and steam) extraction equipment, etc.--to the property, and such capital is specialized to the industry. In the long run, the supply curve will rotate to a more elastic position.

User cost, another important dimension of petroleum supply, is the present value of the difference between the highest anticipated future price and the current price. For example, if the uncontrolled real price is expected to remain constant into the indefinite future, then uncontrolled oil would have a zero user cost, while controlled oil would have a positive user cost. The user cost of controlled oil would equal 44 percent of the uncontrolled price, if decontrol were thought to be three years in the future, if the difference between the uncontrolled and controlled prices were $7 per barrel (the 1975 value), and if the real rate of interest were 10 percent per annum.[1] Reflecting this, the supply curve would shift upward by the amount of the user cost for oil produced under the price control, hence reducing production. In the following discussion we do not distinguish between supply shifts due to this user cost and the natural retrogression discussed above, except to note that this increased user cost is a control-induced phenomenon, whereas natural retrogression occurs independent of controls.

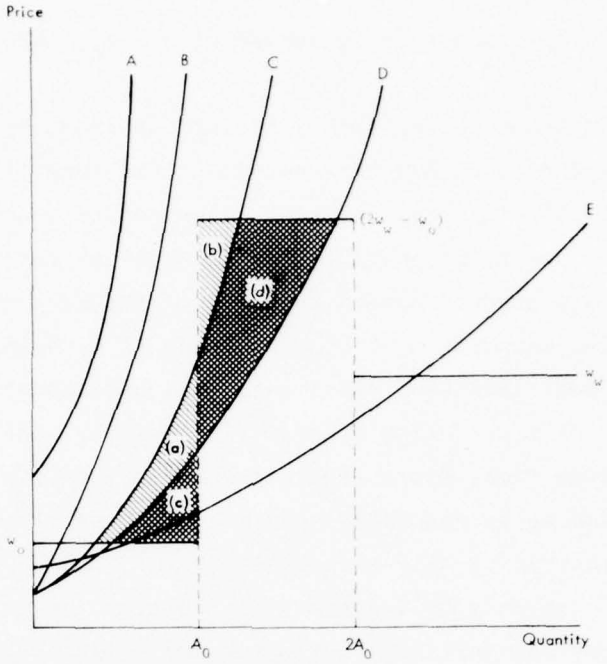


Fig. 3—Prototypical cost curves for producers in 1973+ with base period (1972) production of A_0, with price incentives of 1973 EPAA

Various producers might find themselves in a variety of positions in the current period, even though they had the same base-period production.[2] Production curve A in Fig. 3 portrays a property where a natural retrogression and user cost have been so large that the intercept lies above the control price; no production will be forthcoming. Curve B portrays the case where the backward supply shift was sufficient so that the curve did not pass through higher portions of the discontinuous price line. Such a "constrained" property will produce only Old Oil. Curves C and D represent cases calling for an extra calculation. In these cases, natural retrogression and user cost have moved the production curve backward, but addition of other resources to the property has made the curves more elastic. The decision as to which level of production is best must be made by comparing the net producer surplus obtained from the two production levels. For curve C, the decision is not to produce in the subsidized region, because the area of (a) + (c) exceeds that of (b). For curve D, the decision would be to produce in the

subsidized region at the price ($2w_w - w_o$) because (b) + (d) exceeds (c); such a property would produce Released Oil.

Because of the provisions for Released Oil, it is possible that aggregate domestic production in the United States could have *exceeded* the uncontrolled level. If each property had little or no natural retrogression and if supply elasticities were sufficiently large, then one could indeed have observed this phenomenon. Alternatively, with small supply elasticities, and with significant natural retrogression, one might find diminished domestic production because of the controls.

THE EMPIRICAL CASE: 1973 EPAA

We have acquired data for a single point in time (February 1975) showing the distribution of properties by production status. To be included in this data base, a property must have been producing some New or Released Oil *at some time* during the price controls. Thus properties that would have produced only Old Oil during the period of the controls will be missing from the distribution. As shown in Table 10, of the 25,777 properties listed, some 29 percent were producing only Old Oil in February 1975 (as curve B in Fig. 3, for example), and another 16 percent of the properties are currently producing nothing (as curve A in Fig. 3). Twelve percent of the properties began operation after the base period (New Oil only); they are unaffected by the controls. Finally, 43 percent of the properties are producing some Released Oil; for these properties, we can infer that production has been increased by the controls. Of the properties on this list, almost exactly equal numbers appear to be constrained by the regulations (no production or Old Oil only), and to be subsidized by the regulations (some Released Oil).[3] If the slopes of the marginal cost curves for these properties are all equal, then there was essentially no net effect on aggregate production from the regulations.[4]

Unfortunately, this tabulation does not contain any producing properties that had produced *only* Old Oil since the imposition of the controls. This may be a serious omission, because we estimate that there were 61,000 producing properties at that time, and hence

Table 10

NUMBER OF LEASES PRODUCING SOME NEW AND RELEASED OIL SINCE THE IMPOSITION OF THE PRICE CONTROLS (AS OF FEBRUARY 1975)

Type of Property	Number	Percent
Currently producing Old Oil only	7,369	29
Currently producing New Oil only	3,120	12
Currently producing nothing	4,180	16
Currently producing some New and Released Oil	11,108	43
Total leases	25,777	100

SOURCE: Personal communication to the authors from the FEA staff, November 1975.

that as many as 35,000 properties have produced only Old Oil since the controls began.[5] We consider unresolved the effect of the 1973 price controls on crude oil production.

THE 1975 EPCA--UNAMBIGUOUS REDUCTION OF CRUDE OIL PRODUCTION

The 1975 EPCA placed a price ceiling on previously uncontrolled New Oil (now called Upper Tier Oil), and removed the Released Oil provisions from the law. Thus there is now an unambiguous reduction of crude oil production in the United States because of the following reasons: All domestic crude oil production (except Stripper Oil) is bound by price controls. The incentive to increase production (Released Oil) is gone. The user cost on Old Oil (now Lower Tier Oil) remains at its previous level above $5 per barrel, rising with the advent of decontrol. Since Upper Tier Oil is price-controlled at $11.50 per barrel, with a world price of about $13.50, the user cost (3 years to decontrol at 10 percent per year) is now about $1.50 per barrel. Thus the United States is unambiguously more dependent on foreign oil sources than it would be without the current FEA-administered controls. Table 11 indicates production levels over time.

Table 11

DOMESTIC OIL PRODUCTION BY CATEGORY OF OIL,
OCTOBER 1973 TO JULY 1976
(In bbl per day)

Date	(1) Controlled Old	(2) Released=(New-from Old Properties)	(3) Total Output Old Properties ((1)+(2))	(4) New Oil from New Properties	(5) Stripper	(6) Total (3+4+5)
1973						
October	7010	370	7750	277	1200	9224
November	6504	550	7603	366	1191	9161
December	6434	544	7522	363	1178	9063
1974						
January	5360	893	7147	625	1161	8934
February	5668	914	7496	457	1188	9142
March	5379	986	7351	448	1165	8965
April	5372	985	7342	448	1164	8954
May	5525	891	7307	445	1158	8911
June	5531	790	7111	526	1141	8780
July	5619	790	7199	527	1054	8780
August	5741	696	7133	523	1044	8699
September	5657	675	7008	422	1013	8443
October	5683	689	7061	517	1033	8611
November	5741	686	7112	425	1028	8569
December	5656	685	7027	514	1028	8527
1975						
January	4895	844	6583	592	1013	8439
February	5231	772	6775	858	1029	8575
March	5086	848	6781	678	1017	8476
April	5148	760	6667	675	1013	8440
May	5190	670	6529	753	1088	8371
June	5298	673	6443	673	1093	8409
July	5162	666	6494	666	1166	8327
August	5189	577	6343	741	1153	8237
September	5208	579	6365	661	1157	8266
October	5235	582	6398	748	1163	8310
November	5293	579	6450	662	1158	8271
December	5191	577	6344	742	1153	8239
1976						
January	4433	821	6075	903	1150	8211

Date	Old[a] (Lower Tier) Oil	New[b] (Upper Tier) Oil	Stripper	Total
1976				
February	4590	2459	1147	8196
March	4660	2371	1145	8175
April	4711	2397	1240	8265
May	4716	2399	1241	8264
June	4587	2375	1147	8191
July	4587	2457	1229	8190

SOURCE: Data from FEA (1976).

[a]Old Oil based on 1975 production beginning in February 1976. Released Oil provision eliminated.

[b]Upper Tier is that in excess of 1975 base and is price-controlled at $11.50/barrel.

FOOTNOTES

[1]In general, user cost for controlled oil is

$$UC = \max_{t \geq T} \frac{w_w^t - w_c}{(1 + r)^t}$$

where w_w^t is the uncontrolled real world price in time t, T is the time until decontrol, w_c is the real controlled price, and r is the real interest rate.

[2]The fully integrated firm values all oil at the world price, so long as it is used internally. Hence crude oil production decisions are based upon this world price.

[3]Two possible exceptions to this statement exist. First, some of those properties producing no oil might also have withdrawn from production in a free market. It has been estimated (Harberger, 1974) that the average life of a well is 10 years. Second, some of those properties producing Released Oil might also be in the unconstrained region (as curve F in Fig. 3), and thus unaffected by the regulations.

[4]Production from "constrained" properties decreases by

$$\sum_{i=1}^{n_c} \beta_i^c (w_c - w_w)$$

where β_i^c are the price slopes for the constrained properties, n_c is the number of constrained properties, and w_c and w_w are controlled and world prices, respectively. Production from "subsidized" properties increases by

$$\sum_{j=1}^{n_s} \beta_j^s (2w_w - w_c - w_w) = \sum_{j=1}^{n_s} \beta_j^s (w_w - w_c)$$

where β_j^s are the price slopes for the subsidized properties and n_s is the number of subsidized properties. If $\beta_i^c = \beta_j^s = \beta$ for all i and j, the net effect of the controls on production is

$$\beta(w_w - w_c)(n_s - n_c) \gtrless 0 \text{ as } (n_s - n_c) \gtrless 0$$

[5]The total number of leases on federal lands in 1974 was 156,539 for both oil and gas. Of these 13,127 were *producing* leases (U.S. Department of the Interior, 1975, p. 15).

Federal land leases are about 18 percent of all U.S. oil production (same source, p. 347), the figure varying slightly from year to year. If production per lease is the same on federal as on other leases, then the total number of producing leases in the United States is 13,000/.18 = 73,000 for both oil and gas.

Of these leases, some produce no crude oil. We estimate this by the relative number of producing wells in the country. The total number of producing crude oil wells is about 567,000, and producing gas wells is about 112,000, for a total of 679,000, of which oil wells are 84 percent (American Petroleum Institute, 1971).

Thus, we estimate that there were approximately .84 × 73,000 = 61,000 leases producing oil in the United States in 1975. By subtracting the number of leases reported to the FEA (26,000), we conclude that approximately 35,000 leases have produced only Old Oil since the imposition of the controls.

VIII. U.S. POWER IN WORLD MARKETS FOR CRUDE OIL AND REFINED PRODUCTS

In the preceding sections, we assumed that the United States is a price-taker in world petroleum markets. Under that assumption, predicted effects of petroleum regulation are confined to trade volumes and economic rent transfers. Among crude oil producers and refiners world prices for crude oil and refined products are independent of U.S. petroleum regulation, and domestic prices depart from world prices only by virtue of trade and tax policy.

Aside from recent tariff policy, only the entitlement program and crude oil price controls could have changed domestic prices of crude oil and refined products. Below we discuss how our empirical analysis of banked costs (in Sec. IV) suggests that the United States has had negligible power in world markets. Despite this information, we use an analytic model to study likely U.S. power in petroleum markets. Our analysis concentrates on the entitlement program and tariff policy. We do not analyze the world price effects of domestic crude oil price ceiling, because we cannot reliably estimate the consequent change in domestic production.

EMPIRICAL EVIDENCE THAT THE UNITED STATES HAS LITTLE POWER IN WORLD PRODUCT MARKETS

The regression analysis of banked costs supports the contention that the United States possesses negligible power in world product markets. The estimated coefficient for the world crude oil price states that for every dollar per barrel increase in the marginal cost (world price) of oil, there is about a 45¢ per barrel increase in the price of refined products. Thus no more than 45 percent of the apparent subsidy offered by the entitlement program is passed on as lower prices for refined products. This 45 percent is an upper bound because the apparent subsidy affects only the U.S. refiners (one-fifth of the world market), while changes in the world price of crude oil affect the entire world market for refined

products. Approximately, repealing a subsidy on U.S. use of crude oil has one-fifth the impact on world product prices as increasing the world price of crude oil by an equal amount.[1]

The variable measuring the size of the entitlement subsidy provides a more direct test of U.S. power in world petroleum markets. The amount of the subsidy does not influence the product price ceilings dictated by the FEA, because entitlement revenues and expenditures sum to zero for the refining industry.[2] However if the entitlement subsidy had reduced U.S. product prices, then that price decline should increase the flow of industry banked costs, the difference between the price ceiling and market price. Consequently, a positive coefficient for the subsidy variable reflects U.S. power in world markets. As reported in Sec. IV, this coefficient was indeed positive, of very small magnitude, and was statistically insignificant ($t = .06$).[3]

U.S. MARKET POWER

We will show that the likely magnitude of U.S. market power corroborates the conclusion from our empirical research. We discuss the likely magnitude of import supply elasticities, and then use the results in an analytic study of U.S. petroleum markets.

The United States is a visibly important consumer and producer of crude oil and refined products. In 1974 the United States consumed about 22 percent of total world crude oil production, produced 16 percent of the world's crude oil, and possessed about 21 percent of the world's refinery capacity.[4] Nevertheless, research has yet to determine the extent of U.S. market power. Usually, studies assume that the United States is a price-taker in the world market for crude oil but do not specify U.S. power in world product markets.[5]

This uneven treatment of oil and product imports is unwarranted. Table 12 presents the U.S. trading position with other countries in crude oil and refined products. Once one recognizes that the Caribbean refines oil from the Persian Gulf, U.S. trading patterns in crude oil and products are similar. Data in Table 12 show that

Table 12

SHARE OF U.S. IMPORTS OF CRUDE OIL AND PETROLEUM PRODUCTS, BY COUNTRY OF ORIGIN (1974)

Country	Crude[a] Oil		Refined Product[a]	
Middle East/Africa				
Iran	.13			
Nigeria	.20			
Saudi Arabia	.13		.01	
United Arab Emirates	.02			
Other	.03		.02	
Total Middle East		.51		.03
Caribbean/South America				
Bahamas			.06	
Netherlands Antilles			.20	
Puerto Rico			.03	
Trinidad-Tobago	.02		.07	
Venezuela	.09		.25	
Virgin Islands			.15	
Other			.01	
Total Caribbean		.11		.77
Other				
Canada	.23		.11	
Indonesia	.08		.01	
Italy			.03	
Other	.07		.05	
Total Other		.38		.20
Total		1.00		1.00

SOURCE: American Petroleum Institute, 1975.

[a]Blank space indicates negligible or zero quantity.

there is no presumption that the United States possesses more or less power in the world product market than in the world crude oil market.

Lacking econometric estimates, we turn to theoretical properties of import supply.[6] The import supply of crude oil (or refined products) is the excess supply from the rest of the world. The elasticity of imports with respect to FOB (foreign) price is the weighted

difference between the elasticities of foreign supply (ε_F) and demand (η_F), the respective weights being foreign production and foreign consumption relative to the volume of U.S. imports. The elasticity of imports with respect to the CIF (domestic) price is obtained by multiplying the FOB elasticity by the ratio of CIF to FOB prices.[7] Using 1974 values for all production, consumption, and trade levels, the import supply elasticities for crude oil, ε_M^a, and refined products, ε_M^Q, are described by the following equations:[8]

$$\varepsilon_M^a = \left\{ 13.71\ \varepsilon_F^a - 12.71\ \eta_F^a \right\} K_a \tag{8.1}$$

$$\varepsilon_M^Q = \left\{ 16.88\ \varepsilon_F^Q - 15.87\ \eta_F^Q \right\} K_Q \tag{8.2}$$

The superscript a refers to crude oil, the superscript Q refers to refined products, K_a and K_Q are the ratios of CIF to FOB prices for crude oil and refined products, respectively.

The theoretical expressions provide insight into potential U.S. market power. The elasticity of crude oil imports with respect to CIF price is likely to be large, supporting the common assumption that the United States possesses little market power in crude oil. However, the elasticity of refined product imports with respect to CIF price appears to be equally large.[9] It appears that whenever U.S. petroleum regulation allows links between foreign and domestic markets, analyses need not be concerned with substantial U.S. power in world markets.

THE REPEAL OF THE ENTITLEMENT PROGRAM

Is this level of U.S. market power consistent with our small estimates of the effects of the entitlement program on product prices? We investigate this question by developing a U.S. market equilibrium model that includes a foreign supply of crude oil and refined products. For simplicity, the other factor of production

is assumed immobile internationally. The exact form of the model and the calibration of the parameters are described in the appendix.

The impact of the entitlement subsidy on product price is an application of standard incidence analysis. The amount of the subsidy shifted to consumers, via lower product prices, depends upon the elasticity of demand relative to the elasticity of supply of domestically refined products. The more elastic demand is relative to supply, the smaller the reduction in product price. In our analytic model, the elasticity of demand for domestically refined products depends upon the price elasticity of domestic product demand and import product supply. The domestic supply elasticity depends upon the elasticities of domestic factor supplies for crude and non-crude oil factors, the elasticity of supply of crude oil imports, and the elasticity of factor substitution. By calculating the amount of the entitlement subsidy shifted to consumers, we can predict the change in product price resulting from the repeal of the entitlement program.

The entitlement subsidy is about 6¢ per gallon (Table 4). Below we explore the relationship between the expected increase in product price resulting from repealing this subsidy and assumptions about the supply elasticity of product imports. For the base case, shown in Fig. 4, the elasticities of the model were assigned the following values, on the basis of reported empirical results and inference:[10] Domestic demand (-.5), domestic crude oil supply (1.0), domestic supply of non-crude oil factors (1.0), factor substitution (0). We simulated the relationship for two values for the elasticity of supply of crude oil imports (8 and 16). In light of the above discussion on U.S. market power, these numbers appear to bound the elasticity anticipated *a priori*. Figures 5, 6, and 7, respectively, report simulations for different values of the elasticity of domestic supply of the non-crude oil factor (.5 instead of 1.0), elasticity of domestic demand (-.7 instead of -.5), and the elasticity of factor substitution (.2 instead of 0). Other simulations, not reported, showed that the conclusions were insensitive to the assumed magnitude of the elasticity of domestic crude oil supply. This finding

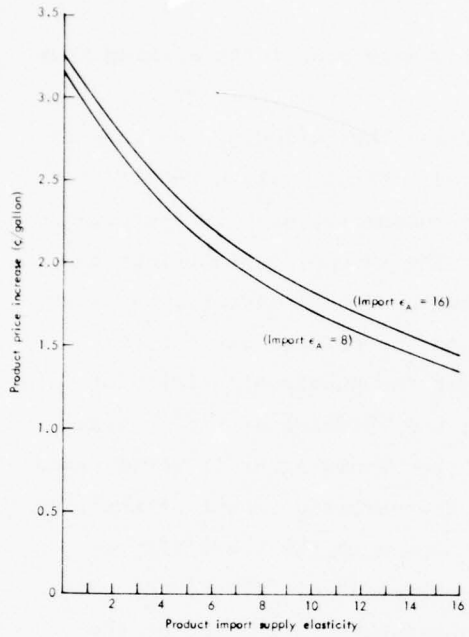


Fig. 4 — Hypothetical product price increase upon repeal of the entitlement program: base case

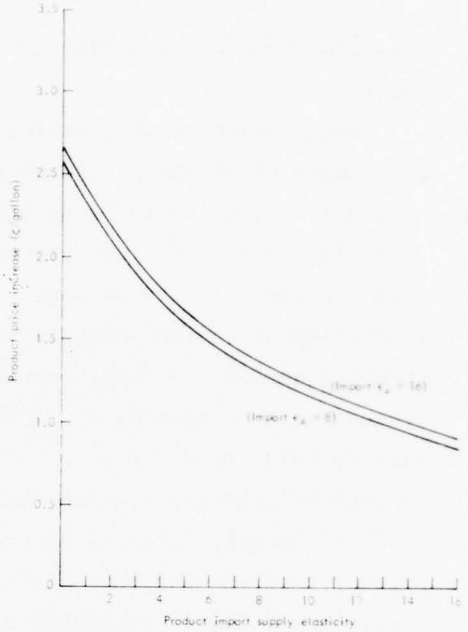


Fig. 5 — Hypothetical product price increase upon repeal of the entitlement program: less elastic domestic supply of factor B

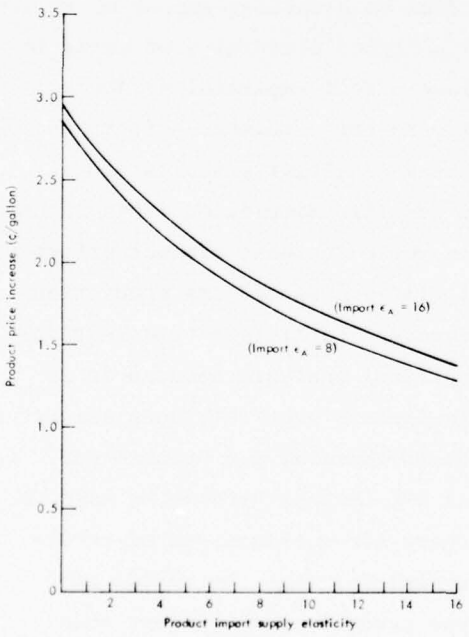


Fig. 6 — Hypothetical product price increase upon repeal of the entitlement program: more elastic domestic demand for product

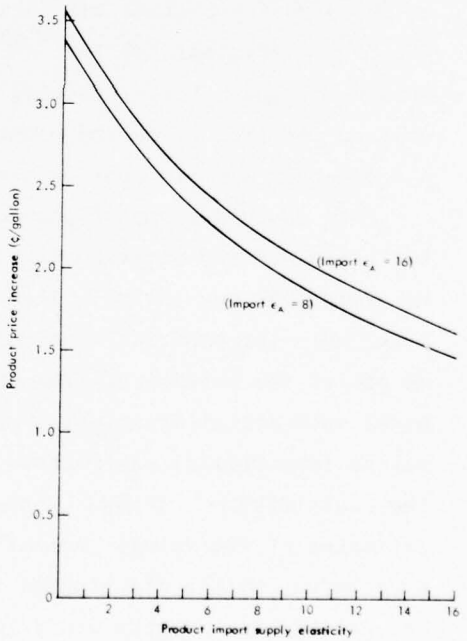


Fig. 7 — Hypothetical product price increase upon repeal of the entitlement program: higher elasticity of substitution in production

reflects the already large crude oil supply elasticity arising from imports.

Examination of the figures provides the following insights for the ranges of parameter values studied. First, only one-half of the original subsidy would be shifted to consumers, even if there were no world trade in refined products. The incomplete shifting results from the inelasticity of supply of non-crude oil factors, the low elasticity of factor substitution, and the price elasticity of domestic demand. Second, knowing that the supply elasticity of product imports must be at least 10, the shifting of the original subsidy is at least 50 percent less than would occur if world trade in refined products did not exist. However, the amount of shifting is only modestly affected by small changes in the elasticity of product imports when that elasticity exceeds 10. Third, the conclusions are fairly insensitive to the assumed magnitude of the supply elasticity of crude oil imports within the range of 8 to 16. Finally, the values of the other parameters have an appreciable effect on the results. Lower elasticities of factor substitution and supply of non-crude oil factors lead to a smaller amount of shifting of the original subsidy, as does a higher elasticity of domestic product demand. Unfortunately, we have direct empirical evidence only on the product demand elasticity, so the simulated effects of all other parameters must be viewed as a sensitivity analysis.

The assumed range of parameters for this simulation implies that the repeal of the entitlement program would increase product prices by 1¢ to 1.5¢ per gallon. These calculations exceed the predictions based upon the empirical analysis discussed earlier in this section. We prefer the prediction from the empirical analysis because it is based upon actual data, while the simulations must rely upon assumed values for critical parameters. This is especially a problem for the elasticity of supply of non-crude oil factors because we have no estimates of its value. Actually, there are combinations of parameter values within the studied range implying that the repeal of the entitlement program would increase product price by less than 1¢ per gallon. Figure 8 reports such a simulation where the

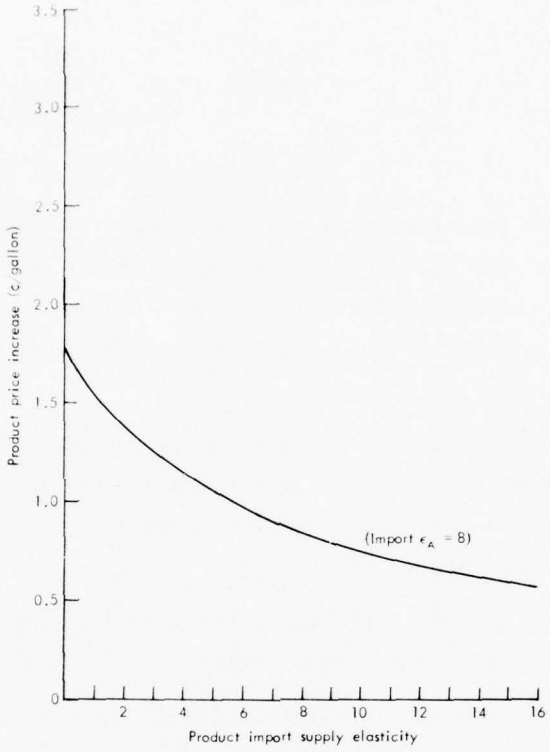


Fig. 8—Hypothetical product price increase upon repeal of the entitlement program: consistent with empirical results

departures from the base case were that the product demand elasticity was -.7 (instead of -.5) and the supply elasticity for non-crude oil factors was .3 (instead of 1.0). These parameters are consistent with the estimated shifting of crude oil price changes from our banked cost regressions.

TARIFF POLICY

Given the presumption of only modest U.S. power in world petroleum markets, tariff policy is the direct tool to affect product prices in the United States. For example, repeal of the current 1.5¢ per gallon tariff on product imports will reduce domestic prices, and could more than offset any upward movement resulting from the repeal of the entitlement program. Changes in the tariff on crude oil imports will not appreciably influence domestic prices of refined products but will affect domestic prices of crude oil.

FOOTNOTES

[1]According to this reasoning, only 9 percent (the product of the .2 and .45) of the entitlement subsidy is passed on as lower world prices for refined products. This implies that the repealing of the entitlement program would increase world product prices by .05¢/gal.

[2]The banked costs of individual firms are affected by the entitlement program. A firm's price ceiling is increased (decreased) by an amount equal to entitlement expenditures (receipts) divided by the firm's volume of output.

[3]Using the estimated coefficient, the repeal of the entitlement program would increase world product prices by .02¢/gal.

[4]Data taken from Council on International Economic Policy (1975). The U.S. consumption share of total world crude oil production was estimated by summing U.S. production (Table 65) and net U.S. imports (Table 76), and dividing this sum by total world production of crude oil (Table 65).

[5]See *Cabinet Task Force on the Oil Import Quota Question* (1971), and Adelman (1972).

[6]Most empirical analyses of import supply elasticities have not considered individual products. Most studies show that the United States is essentially a price-taker for its aggregate imports, the point estimate of the aggregate supply elasticity of imports exceeding 8.0 (Heller, 1974). Perhaps the presence of import quotas during the late 1950s to the early 1970s has discouraged studies from estimating import supply elasticities for crude oil and refined products, because traditional econometric techniques require that markets not be subject to non-price regulation.

[7]The results are derived in the following manner:

Let M = import quantity

S_F = foreign production
D_F = foreign consumption
P_F = FOB price
P_D = CIF price

Thus,

$$M = S_F(P_F) - D_F(P_F)$$

$$\frac{\partial M}{\partial P_F} = \frac{\partial S_F}{\partial P_F} - \frac{\partial D_F}{\partial P_F}$$

$$\frac{P_F}{M}\frac{\partial M}{\partial P_F} = \left[\frac{\partial S_F}{\partial P_F}\frac{P_F}{S_F}\right]\frac{S_F}{M} - \left[\frac{\partial D_F}{\partial P_F}\frac{P_F}{D_F}\right]\frac{D_F}{M} = \varepsilon_M$$

$$\frac{\partial M}{\partial P_D}\frac{P_D}{M} = \frac{\partial M}{\partial P_F}\frac{P_F}{M}\frac{\partial P_F}{\partial P_D}\frac{P_D}{P_F} = \varepsilon_M \frac{P_D}{P_F}$$

because we assume that $\partial P_F/\partial P_D = 1$ (per unit transportation costs are independent of the volume of U.S. imports).

[8]The following data were used in the calculation of the ratios reported in the text. The data were taken from the Council on International Economic Policy (1975).

	Crude Oil Production (1000 bbl/day)	Crude Oil Imports (Exports) (1000 bbl/day)	Product Imports (Exports) (1000 bbl/day)
Rest of World	46,880	(3,419)	(2,575)
United States	8,890	3,419	2,575

The data included production and trade with the Communist Bloc. We believe that its inclusion is appropriate because 40 percent of USSR's exports of crude oil are shipped to Western countries (primarily Western Europe), most of the People's Republic of China's

exports of crude oil are shipped to Japan, and Eastern Europe engages in trade with Western Europe. See Central Intelligence Agency (1975).

[9]We reach these conclusions by evaluating the formulas at low values for price elasticities of foreign consumption and foreign production. Assuming that $\eta_F^a = \eta_F^Q = -.5$, $\varepsilon_F^a = \varepsilon_F^Q = .2$, and the ratio of CIF to FOB prices is 1.1, the formulas imply that $\varepsilon_M^a = 10.0$, and $\varepsilon_M^Q = 12.4$. These elasticities imply only modest market power for the United States, with the marginal factor costs of crude and product imports exceeding their world prices by 10 percent and 8 percent, respectively.

[10]The assumed values for the elasticities of product demand and supply of crude oil, respectively, originate from empirical research reported by Kennedy (1974) and the *Cabinet Task Force on the Oil Import Quota Question* (1971). The assumption about the supply of non-crude oil factors originates from the presumption that this supply cannot be more elastic than the supply of crude oil. Otherwise, a larger portion (than the estimated 45 percent) of higher crude oil prices would have been passed on as higher product prices. Finally, there is an extremely low elasticity of substitution between crude and non-crude oil factors in petroleum refining (see note 3, Sec. IV).

IX. WHAT THE CONTROLS DID ACHIEVE

SUMMARY

Our analysis shows that the ceilings on refinery prices have not been binding, and hence that no consequent effects on retail product prices have occurred.[1] The possibility exists that the entitlement program, by subsidizing domestic use of crude oil, has slightly lowered the price of refined products. This appears to be unimportant because the United States has negligible power in world refined product markets. We showed that this program has altered trade flows, rather than product prices.

The controls on crude oil prices may have had some effect on domestic crude oil production, but the direction of the effect from 1973 to 1975 was both theoretically and empirically ambiguous. The 1976 EPCA unambiguously reduces domestic production of crude oil. If the United States possessed significant amounts of power in the world crude oil markets, reduced production could cause an increase in world crude oil prices, and hence world refined product prices. Our analyses suggest that this effect is likely to be small, if it indeed exists.

The results of our inquiry imply that the policy debate about decontrol has been erroneously concerned with increases in refined product prices. However, one should not conclude that we believe the FEA controls to constitute benign neglect of the U.S. petroleum industry. Quite the contrary, the controls have had substantial impact, but on redistribution of profits in the crude oil and refining industries, rather than on product prices. The combination of crude oil and product tariffs, crude oil price controls and allocation systems, and the entitlement program, has served to redistribute income among petroleum industry corporations.

Although we cannot obtain firm-specific information sufficient to characterize each company's net position, we are able to reconstruct the effects of the program for the industry as a whole. Table 13 compiles our results from earlier sections on the profit

Table 13

EFFECTS OF 1973 EPAA REGULATIONS ON PROFITS
OF CRUDE OIL AND REFINERY FIRMS

Aspect of Controls	Crude Oil Producers	Refiners
Crude Oil Tariff		
Profit effect (1st order)	$T_a(Q_o+Q_n)$	$-T_a(Q_o+Q_n+Q_I)$
Profit rate at 12/75 levels	+$6.6 billion/yr	-$9.5 billion/yr
Profit rate at 1976 levels	+$.6 billion/yr	-$0.9 billion/yr
Product Tariff		
Profit effect (1st order)	0	$T_q(Q_o+Q_n+Q_I)$
Profit rate, 1975 and 1976	0	+$2.7 billion/yr
Net Position from Tariffs	$T_a(Q_o+Q_n)$	$(T_q-T_a)(Q_o+Q_n+Q_I)$
1975 rate of protection	$2.21/bbl	-$1.58/bbl
1975 profit rate	$6.6 billion	-$6.8 billion/yr
1976 rate of protection	$0.21/bbl	+$0.42/bbl
1976 profit rate	$0.6 billion/yr	$1.8 billion/yr
Old Oil Allocation Plan		
Profit effect	$-(w_w+T_a-w_c)Q_o$	$+(w_w+T_a-w_c)Q_o$
Profit rate 1975[a,b]	-$14 billion/yr	+$14 billion/yr
Profit rate 1976[a,b]	-$11 billion/yr	+$11 billion/yr
Entitlement Program	0	($1.5 billion/yr *within* refining industry)
1975 within industry transfer efficiency loss	0	-$.2 billion

[a]Profit rate at prices prevailing in late 1975 and early 1976. Difference between years reflects removal of $2 per barrel supplemental crude oil tariff.

[b]Upper bound estimate of actual interfirm transfer. For firms using Old Oil produced by themselves or subsidiary firms, no profit transfer takes place except in an accounting sense. Actual profit transfer may be less than half of these amounts.

DEFINITIONS: T_a = tariff on crude oil; T_q = tariff on refined products; Q_o = Old Oil quantity; Q_n = New Oil quantity; Q_I = imported oil quantity; w_w = world price of crude oil; w_c = controlled price of Old Oil.

effects of various regulations. The calculations are presented in detail in the appendix. Only the crude oil and product tariffs significantly altered profitability of the industry as a whole. The crude oil pricing and allocation programs merely pass profits from crude producers to refiners (often the same corporate identity because of vertical integration). The entitlement program redistributes profits among refiners.[2] It is certain that the industry will be effectively split on its position because of the multiplicity of programs affecting profitability. This was the case during the discussions in Congress preceding the enactment of the 1975 law itself.[3] Perhaps this industry fragmentation explains why the 1975 EPCA did not greatly modify the price controls or the allocation and entitlement programs. Instead, the major policy modifications centered on tariff policy.

For the industry as a whole, the 1976 tariffs lead to higher profitability than did previous tariffs. Repeal of the $2 supplemental tariff left refiners with a positive net rate of protection against foreign competition, although reducing the protection enjoyed by crude oil producers. This tariff change obviously altered the distribution of total profits among crude oil producers and refiners.

UNRESOLVED ISSUES

Our analysis has pinpointed areas where more extensive research could refine the estimates of the effects of the petroleum industry regulations. Better estimates of U.S. power in world markets would be useful. Estimates should be made of the magnitude of the effect that controls have on U.S. crude oil production, and integrated with the market power analysis to estimate product price effects. The analysis would be furthered by knowledge of factor substitution possibilities, and the elasticity of supply of non-crude oil factors to the United States and world markets.

Finally, we note a puzzle in political economy which has been so persistent as to demand attention--the ability of small and

"independent" refiners to reap economic favors from the political process. Favorable treatment of this group existed with the oil import quota schemes (Dam, 1971) and extended through exemptions from import license fees and entitlement payments under current programs; their ability to reap these favors remains a puzzle.

FOOTNOTES

[1]The temporarily binding retail price controls during the Arab embargo, leading to queueing at service stations, is the major exception to this statement.

[2]A $0.2 billion welfare loss to refiners also arises because of induced inefficiency.

[3]One indication is given in testimony by a Federal Trade Commission (FTC) staffer. Of 49 refiners surveyed by the FTC, 37 percent felt that upon decontrol, profits would increase; 52 percent felt profits would decrease; 11 percent felt there would be no change (U.S. Senate, 1975b).

APPENDIX

DATA SOURCES AND TRANSFORMATION FOR BANKED COST REGRESSIONS

1. The dependent variable is derived from monthly levels of banked costs for the 30 largest U.S. refiners for January 1974 through January 1976 (FEA, 1976). Production levels for those 30 firms were obtained from monthly reports of crude oil inputs published in monthly entitlement reports from the FEA (*Federal Register*, monthly). The firms obtaining entitlements were rank-ordered on total production, and the volume of output of the top 30 firms was used as a divisor for the banked cost data. Banked costs were deflated by the general price level in the United States. The dependent variable used in the regressions was the change in real banked costs per gallon of product sold monthly for these 30 firms. The fraction of output accounted for by the top 30 firms averaged 86.65 percent, with a standard deviation of 1.47 percent, a minimum of 83.8 percent, and a maximum of 88.7 percent. Gallons of production were calculated by multiplying daily average barrels of production (FEA, 1976) by the number of days in each month, by the above-described fraction, and by 42 gallons per barrel.

2. The per-gallon price of imported crude oil, exclusive of tariff, was derived from FEA (1976). The nominal crude oil tariff imposed by the United States was subtracted from the reported crude oil price, and the difference deflated by the CPI. The variable used in the regression is the deviation of this tariff-exclusive real price from the base-period price per gallon of $.0951 in May 1973.

3. The crude oil tariff series was derived as follows: The basic license fee was retained throughout the period, moving from 10.5¢ to 21¢ (CFR Sec. 213.35). The supplemental fee of $1 was added in February 1975, and then increased to $2 in May 1975; it was eliminated in January 1976. Certain refiners are exempted from paying the basic license fee on the first portion of their imports, but insofar as we can determine, these are all infra-marginal exemptions, and the relevant

marginal price is the full basic fee plus relevant supplemental tariffs. The tariffs were placed in real terms by the cost of living deflator. The variable entering the regression is the difference of the current tariff from the base-period level of $.0019 per gallon.

4. The product tariff is a volume-weighted average of the tariffs on gasoline and on other products, as derived from federal regulations (CFR Sec. 213.35). This tariff increased over time to its current level of $.63 per barrel (1.5¢ per gallon) for all products, but the level over time varied by product. This tariff was also placed on real terms, and the variable entering the regression was based upon the difference between current tariff and the volume-weighted fee in the base period, namely, $.00552 per gallon.

5. The level of economic activity is an average of OECD countries, for which data were available, weighted by initial levels of economic activity (OECD, 1976). The weights used were: Canada, .0481; United States, .4707; Japan, .1537; Australia, .0265; France, .0494; West Germany, .1335; Italy, .0501; Sweden, .0137; United Kingdom, .0543. The variable used in the regression is the difference between the current level and the base-period (May 1973) level, 99.98. Since the OECD data are quarterly only, the monthly series we use imputes the quarterly datum to each month within the quarter. This should generate errors in the variable, bias the coefficient towards zero, and reduce the computed t-statistic on the regression coefficient. The errors-in-variables will transfer bias to the other coefficients, given the correlations among the explanatory variables. The crude oil price and deflator coefficients are biased towards zero, and the crude oil tariff coefficient is biased away from zero.

6. The general price level for the United States was taken from the *Federal Reserve Bulletin*. This variable was used as a deflator for all price or expenditure data except OECD member nation economic activity levels, which were already in real terms. The variable entering the regression is the value of the price deflator in month i less the base-period level of 131.5.

7. The monthly base-period imports of refined products into the United States were taken from FEA (1976), p. 8, for each month in 1973. The variable in the regression is the ratio of these base-period imported refined product volumes to the total domestic crude oil inputs, for each month in the 1974-1975 period. Crude oil use was derived from the same source, p. 6.

Summary statistics for these data appear in Table 14. Regressions were estimated on two separate regression programs utilizing

Table 14

SUMMARY STATISTICS FOR BANKED COST REGRESSION DATA

Variable	Mean	Standard Deviation	Minimum	Maximum
(1) Monthly change in banked cost ($/gal of product)	.00224	.00853	-.01141	.01874
(2) Real crude oil price ($/gal) (change from base period)	.09345	.01437	.06617	.11554
(3) Real crude oil tariff ($/gal) (change from base period)	.01238	.01363	.000249	.03113
(4) OECD economic activity index (change from base period)	-6.551	3.5331	-12.073	.02000
(5) General price level (U.S.) (change from base period)	.22999	.07948	.08200	.348
(6) Base-period refined product import volumes : current monthly crude oil inputs to refineries	.24539	.03327	.20736	.32742
(7) Real product tariff ($/gal) (change from base period)	.0008	.0016	-.0018	.0035
(8) Entitlement subsidy ($/gal) (base period = 0)	.023	.020	0.0	.044

Table 14 (continued)

CORRELATION MATRIX OF EXPLANATORY VARIABLES[a]

	Real Crude Price	Real Crude Tariff	OECD Economic Activity	U.S. General Price Level	Product Imports : Refinery Input	Real Product Tariff	Entitlement Subsidy
Real crude price	1.00	-.56	.23	.14	-.53	.01	-.05
Real crude tariff	-.71	1.00	.21	.20	-.47	.11	.19
OECD economic activity	.54	-.67	1.00	-.19	.60	.36	-.69
U.S. general price level	-.61	.86	-.72	1.00	.19	.71	.08
Product imports/ refinery input	-.19	-.24	.35	-.17	1.00	-.27	.43
Real product tariff	-.60	.86	-.69	.96	-.20	1.00	.43
Entitlement subsidy	-.69	.84	-.82	.91	-.10	.91	1.00

[a]Simple correlations below diagonal, partial correlations above diagonal.

different matrix inversion algorithms, since the data set was highly multicollinear and ill-conditioned. (The results were identical.) Several tests were performed to ascertain that the residuals were randomly distributed with constant variance. First, the Durbin-Watson test of 2.31 is in the region of acceptance of the null hypothesis (no autocorrelation) for $\alpha = .01$. We further calculated the simple correlation of the once- and twice-lagged residuals and found the first-order correlation to be .2 and the second-order correlation to be .08. Neither of these correlations is significantly different from zero at $\alpha = .1$. To test for heteroskedasticity, we regressed the squared residuals from the original regression against the explanatory variables in the original regression, against the original dependent variable itself, and against the combination. In no case was a coefficient in this test significantly different from zero. Hence, we accepted the hypothesis of homoskedasticity. The plotted residuals also have the general appearance of normality.

demand for product

substitution in production

ANALYSIS OF THE ENTITLEMENT PROGRAM

We use a non-cooperative game to model the refiner's response to the entitlement program. As described in the text, this decision is independent of his expectations about the behavior of other refiners. Consequently, we do not model these expectations.

The profit function for a refiner i, one of many in the domestic industry, is:

$$\pi_i = (q_i^o + q_i^n)\, P + P_E \left[- q_i^o + \frac{\bar{q}_o}{\bar{q}_o + \bar{q}_n} \cdot (q_i^o + q_i^n) \right] \qquad (A.1)$$

$$- [q_i^o w_o + q_i^n w_w] - C(q_i^o + q_i^n)$$

where

q_i^o is the firm's quantity of Old Oil (fixed)

q_i^n is the firm's quantity of New Oil and imported oil[1]

P is the market price of output, assumed constant

w_o is the fixed price of Old Oil

w_w is the world price of oil

P_E is the legally fixed price of entitlements

$\bar{q}_o = \sum_{i=1}^{m} q_i^o$ = market quantity of Old Oil

$\bar{q}_n = \sum_{i=1}^{m} q_i^n$ = market quantity of New Oil and imported oil

$\bar{q} = \bar{q}_o + \bar{q}_n$, and

$C(\cdot)$ is a marginal cost function for non-crude oil costs of refining.

The first term in brackets in Eq. (A.1) represents the firm's net entitlement position. The endogenous variable for each firm is q_i^n. Profit maximization for firm i requires $\partial \pi_i / \partial q_i^n = 0$, which is given by:

$$\frac{\partial \pi_i}{\partial q_i} = P + P_E \cdot \left[- \left(q_i^o + q_i^n \right) \frac{\bar{q}_o}{(\bar{q}_o + \bar{q}_n)^2} + \frac{\bar{q}_o}{(\bar{q}_o + \bar{q}_n)} \right] \tag{A.2}$$

$$- [w_w + C'(q_i)] = 0$$

Notice that for any firm *taken alone*, the marginal revenue from expanding output includes a varying term involving P_E, so that entitlements subsidize additional purchases of q_i^n. However, this is only a representative firm, and the solution for the industry as a whole must take into account all firms' behavior.

In an uncooperative game, this is accomplished by summing up the first-order conditions for the industry, i.e.

$$nP + P_E \cdot \left[\frac{n \cdot \bar{q}^o}{\bar{q}_o + \bar{q}_n} - (\bar{q}_o + \bar{q}_n) \frac{\bar{q}_o}{(\bar{q}_o + \bar{q}_n)^2} \right] - n [w_w + C'(q_i)] \tag{A.3a}$$

$$= nP + P_E \cdot \left[(n - 1) \frac{\bar{q}_o}{\bar{q}_o + \bar{q}_n} \right] - n [w_w + C'(q_i^o + q_i^n)] = 0$$

Dividing by n and rearranging gives

$$P = w_w + C' - \frac{\bar{q}_o}{\bar{q}_o + \bar{q}_n} \cdot P_E \cdot \frac{(n - 1)}{n} \tag{A.3b}$$

The first two terms on the right-hand side of Eq. (A.3b) represent marginal resource costs of production. The third term

$$\frac{\bar{q}_o}{\bar{q}_o + \bar{q}_n} \cdot P_E \cdot \frac{(n - 1)}{n}$$

represents the subsidy to the firm arising from the entitlement program, and is equal to $P_E \cdot F \cdot (n - 1)/n$, where F is the FEA announced

monthly industry fraction of Old Oil to total oil inputs. The ratio $(n - 1)/n$ represents the output fraction for the industry exclusive of the firm in question.[2] The solution to this non-cooperative game leads to the following conclusion. When the industry faces a lump-sum subsidy distributed relative to the amount of a particular input for each firm, competitive conditions shift each firm's marginal cost curve downward. The amount of the shift depends upon how the subsidy is administered.

It is also easily shown that if a refiner is constrained by the price ceiling, there is no subsidy, since entitlement receipts (payments) enter the price control formula. Since this does not appear to be a relevant condition in the United States, we omit the proof.

INDUSTRY PROFITS

Calculations of the effects of FEA regulations on industry profits are based upon first-order approximations of effects of the programs on profit functions. The basic framework used is shown by profit functions for crude producers and refiners:

$$\pi_a = (w_w + T_a)(Q_o + Q_n) - C_A(Q_o + Q_n) - (w_w + T_a - w_c)Q_o \qquad \text{(A.4a)}$$

$$\pi_q = (P + T_q)(Q_o + Q_n + Q_I) - (w_w + T_a)(Q_o + Q_n + Q_I) - C_Q(Q_o + Q_n + Q_I) + (w_w + T_a - w_c)Q_o \qquad \text{(A.4b)}$$

where the last term in each function reflects the transfer arising from the Old Oil allocation program. This formulation abstracts from the entitlement program, which was discussed above. Terms in these expressions are:

w_w = world price of crude oil
P = world price of refined product
T_a = domestic tariff on crude oil
T_q = domestic tariff on refined products
w_c = controlled price of Old Oil

Q_o = quantity of Old Oil
Q_n = quantity of New Oil
Q_I = quantity of imported oil
C_A = cost function for crude oil production, and
C_Q = non-crude oil cost function for refining.

Profit effects and effective rates of protection are derived through Taylor series expansion of the profit functions as the tariffs are altered. We assume that the United States possesses no power in world markets. For crude oil producers, the first-order approximation of the profit effect is $d\pi_a = (Q_o + Q_n)dT_a$, where second-order terms reflecting profits from optimal expansion are positive. Hence the first-order approximation understates the profit effects of the tariff. The Old Oil allocation program transfers to refiners the portion of profits measured by $Q_o dT_a$.

Since crude oil is an input to refiners, the tariff on crude oil reduces profits of refiners. The first-order approximation of this effect is $d\pi_q = -dT_a(Q_o + Q_n + Q_I) + dT_a Q_o$. (Second-order terms are positive.) The last term represents an interaction between the allocation program and the tariff structure. For purposes of computing effective rates of protection, we have assigned the entire factor cost to refiners of an increase in T_a, and then add back $T_a Q_o$ as an effect of the allocation program. Although this is primarily a bookkeeping exercise, our intention is to have the rate of protection calculation invariant to the existence of the allocation program.

For refiners, a change in the product tariff T_q is given (to a first-order approximation) by $d\pi_q = (Q_o + Q_n + Q_I)dT_r$, with second-order terms reflecting optimal expansion being positive.

The following data were used in the calculation of profit effects of the tariff policy.

Old Oil (Q_o)	1.85 billion bbl/yr
Uncontrolled oil (Q_n). . .	1.15 billion bbl/yr
Imported oil (Q_I).	1.40 billion bbl/yr
Refined product (Q). . . .	4.30 billion bbl/yr
Crude oil tariff (at peak) 1975	$2.21/bbl

Crude oil tariff 1976. . . $0.21/bbl

Refined product tariff, 1975 (peak) and 1976 . . $0.63/bbl

First-order approximations for the effects of profits from the 1975 peak tariffs are as follows: crude oil producers ($2.21 × 3 billion = $6.63 billion per year), refiners from product tariff ($0.63 × 4.3 billion = $2.7 billion per year), refiners from crude oil tariff (-$2.21 × 4.3 billion = -$9.5 billion per year).

Since a significant fraction of the petroleum industry is vertically integrated, we also calculate the effective rate of protection for the petroleum industry taken as a whole. To do this, we compute a profit/loss on imported crude oil (on which the tariff is paid), but which nets to zero for domestic crude oil in the integrated industry. Imports account for approximately one-third of total oil used. Thus the effective rate of protection for the petroleum industry is (at maximum rates in 1975) -$2.21 × .33 + $0.63 = $0.10 per barrel. At tariff rates in force in 1976 ($0.21 per barrel of crude oil, $0.63 per barrel of product), the effective rate of protection is -$0.21 × .33 + $0.63 = $.56 per barrel. For domestic production of 4.3 billion barrels, this amounts to $2.4 billion per year. Refiners gain $2.7 billion from the product tariff but lose $0.9 billion from the crude oil tariff, for a net gain of $1.8 billion. Crude oil producers gain $0.6 billion from the crude oil tariff. For this calculation, the allocation program is irrelevant.

ANALYTIC STUDY OF THE REPEAL OF THE ENTITLEMENT PROGRAM

To study analytically impacts of possible world market power on our conclusions regarding decontrol, we apply the model in Sec. III to U.S. markets, with extensions to account for foreign supply of crude oil and refined products. The other factors of production are assumed to be immobile internationally. We begin by specifying the relationships among the prices in the model, then present the factor demand and supply equations. Finally, we derive the relationships

among domestic factor and product prices and the subsidy offered by the entitlement program.

The relationships among foreign and domestic prices reflect the presence of the tariffs, the entitlement program, and the zero profit condition. Because of tariffs,

$$P_w = P_d - T_q \tag{A.5a}$$

$$w_w^a = w_d^a - T_a \tag{A.5b}$$

where

P_w is the world price of products (inclusive of transportation costs)

P_d is the domestic price of refined products

T_q is the tariff levied on the imports of refined products

w_w^a is the world price of crude oil (inclusive of transportation costs)

w_d^a is the domestic price of crude oil

T_a is the tariff levied on crude oil.

Because of the entitlement program, the refiner's price of crude oil differs from the domestic price by the amount of the subsidy offered by the entitlement program, so that

$$w_{ds}^a = w_d^a - s_a \tag{A.6}$$

where

w_{ds}^a is the subsidy-inclusive price of crude oil to domestic refiners and

s_a is the subsidy offered by the entitlement program.

Changing the subsidy yields the following equations for price changes (an asterisk represents percentage change):

$$P_w^* = \beta_q P_d^* \tag{A.7a}$$

$$w_w^{a*} = \beta_a w_d^{a*} \tag{A.7b}$$

$$w_{ds}^{a*} = \beta_s w_d^{a*} - \frac{ds_a}{w_d^a - s_a} \tag{A.7c}$$

where

$$\beta_q = \frac{P_d}{P_w}$$

$$\beta_a = \frac{w_d^a}{w_w^a}$$

$$\beta_s = \frac{w_d^a}{w_d^a - s_a}$$

Finally, the zero profit condition relates the domestic product price to the domestic factor prices in the following manner:

$$P_d^* = \alpha_A w_{ds}^{a*} + (1 - \alpha_A) w_d^{b*} \tag{A.8}$$

where

α_A is the cost share of factor A in refining, and

w_d^b is the domestic price of factor B.

Supply conditions reflect foreign and domestic sources of supply. The import supply equations are:

$$M_a^* = \beta_a \varepsilon_w^a w_w^{a*} \tag{A.9a}$$

$$M^* = \beta_q \varepsilon_w P_w^* \tag{A.9b}$$

where

M_a is the volume of imports of crude oil

ε_w^a is the supply elasticity of crude oil imports

M is the volume of imports of refined products

ε_w is the supply elasticity of refined product imports.

The domestic factor supply conditions are:

$$A_d^* = \varepsilon_d^a w_d^{a*} \tag{A.10a}$$

$$B_d^* = \varepsilon_d^b w_d^{b*} \tag{A.10b}$$

where

A_d is the domestic supply of crude oil

B_d is the domestic supply of the other factor

ε_d^i is the elasticity of domestic supply for the ith factor.

Letting m_a denote the share of total crude oil supply that is imported, the supply conditions for crude oil are given by:

$$A^* = \left\{ (1 - m_a)\varepsilon_d^a + m_a \beta_a \varepsilon_w^a \right\} w_d^{a*} \tag{A.11}$$

Equations (A.10b) and (A.11) thereby describe the supply of both factors to domestic refining, in terms of domestic prices.

Factor demands represent factor substitution possibilities as well as demand for domestically refined products. The factor demand equations are:

$$D_A^* = (1 - \alpha_A)\sigma(w_d^{b*} - w_{ds}^{a*}) + Q_d^* \qquad \text{(A.12a)}$$

$$D_B^* = \alpha_A\sigma(w_{ds}^{a*} - w_d^{b*}) + Q_d^* \qquad \text{(A.12b)}$$

where

σ is the elasticity of factor substitution, and
Q_d is the demand for domestically refined products.

Since demand for domestically refined products represents the excess of domestic demand for products over product imports, Q_d is described by the following equation:

$$Q_d^* = \left\{ \frac{\eta_d - \beta_q \varepsilon_w m}{(1 - m)} \right\} P_d^* = P_d^* \eta_r \qquad \text{(A.13)}$$

where

η_d is the elasticity of demand for refined products
m is the fraction of domestic product consumption that is imported, and
η_r is the demand elasticity facing domestic refiners.

The factor demands by the domestic refining industry can be obtained by substituting for Q_d^* (from Eq. (A.13)) and P_d^* (from Eq. (A.8)) in Eqs. (A.12a) and (A.12b).

The resulting factor demands and supplies can be used to study

the repeal of the entitlement program. The disturbance to the system is the change in the subsidy, which affects factor and product prices by increasing the supply price of crude oil to domestic refiners. The solution to the model offers the following expressions for how domestic prices are related to the subsidy:

$$w_d^{a*} = \left[E_{BB} \left\{ (1 - \alpha_A)\,\sigma - \alpha_A \eta_r \right\} + E_{AB}\alpha_A(\sigma + \eta_r) \right] \frac{ds_a}{(w_d^a - s_a)} \cdot \frac{1}{\Delta} \tag{A.14a}$$

$$w_d^{b*} = \left[E_{AA} \left\{ -\alpha_A(\sigma + \eta_r) \right\} - E_{BA} \left\{ (1 - \alpha_A)\,\sigma - \alpha_A \eta_r \right\} \right] \frac{ds_a}{(w_d^a - s_a)} \cdot \frac{1}{\Delta} \tag{A.14b}$$

$$P_d^* = \alpha_A \beta_a w_d^{a*} + (1 - \alpha_A) w_d^{b*} - \frac{\alpha_A ds_a}{(w_d^a - s_a)}$$

where

$$E_{AA} = (1 - m_A)\varepsilon_d^a + m_A\, \varepsilon_w^a\, \beta_a + (1 - \alpha_A)\sigma\beta_s - \alpha_A\, \beta_s\, \eta_r$$

$$E_{BB} = \varepsilon_d^b + \alpha_A\sigma - (1 - \alpha_A)\eta_r$$

$$E_{AB} = -(1 - \alpha_A)(\sigma + \eta_r)$$

$$E_{BA} = -\alpha_A\beta_s(\sigma + \eta_r)$$

$$\Delta = E_{AA}E_{BB} - E_{AB}E_{BA}$$

The simulations reported in Sec. VIII are based upon these equations.

The expressions in Eqs. (A.14a) to (A.14c) contain known and unknown parameters that are listed in Table 15. The known parameters were given their 1975 values, where applicable. The elasticity of

Table 15

PARAMETERS CONTAINED IN THE RELATIONSHIP BETWEEN THE ENTITLEMENT SUBSIDY AND DOMESTIC PRODUCT PRICE

Known	Unknown
$\beta_a = \frac{w_d^a}{w_w^a} = 1.156$	ε_w^a (supply elasticity of crude oil imports)
	ε_w (supply elasticity of product imports)
$\beta_q = \frac{P_d}{P_w} = 1.041$	σ (elasticity of factor substitution in domestic refining)
$\beta_s = \frac{w_d^a}{(w_d^a - \beta_a)} = 1.232$	ε_d^b (elasticity of supply of other factor of production)
$\alpha_A = .5$	
$\eta_d = .5$	
$m = .148$	
$m_A = .40$	
$\varepsilon_d^a = 1.0$	

domestic demand for products and the elasticity of domestic production were given values estimated by previous research. The text reports sensitivity analysis on the unknown parameters.

FOOTNOTES

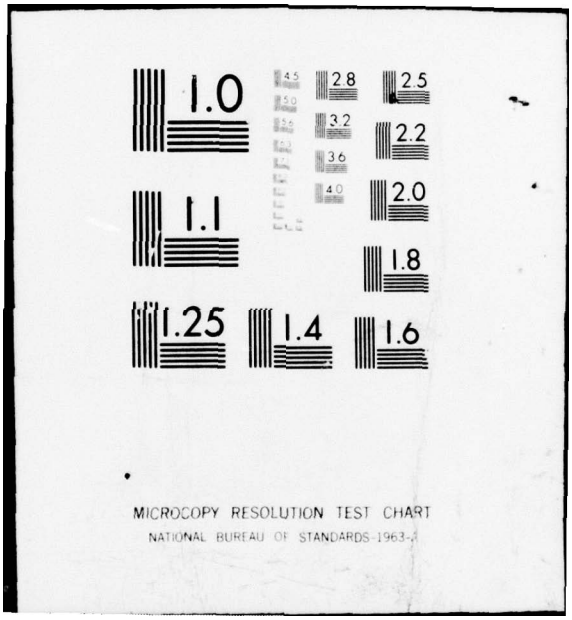
[1] Output = $q_i^o + q_i^n$, since products are produced barrel-for-barrel by crude oil inputs.

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PETROLEUM REGULATION: THE FALSE DILEMMA OF DECONTROL,(U)
JAN 77 C E PHELPS, R T SMITH
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

[2]The largest firm in the U.S. refining industry sells about 9 percent of total product, so that (n - 1)/n, the fractional effect of the "entitlement effect" relative to the pure competitive case is 91 percent. Thus, the entitlement program offers the largest firm nearly as large a per-unit subsidy as the smallest firms in the industry.

BIBLIOGRAPHY

Adelman, Morris A., *The World Petroleum Market*, The Johns Hopkins University Press, Baltimore, Maryland, 1972.

Alchian, Armen, and William R. Allen, *Exchange and Production Theory in Use*, Wadsworth Publishing Co., Inc., Belmont, California, 1969.

American Petroleum Institute, *Annual Statistical Review: Petroleum Industry Statistics*, Washington, D.C., 1965-1977.

American Petroleum Institute, *Petroleum Facts and Figures, 1971 Edition*, Washington, D.C., 1971.

Barzel, Yoram, "A Theory of Rationing by Waiting," *Journal of Law and Economics*, Vol. 17, No. 1, April 1974.

Cabinet Task Force on the Oil Import Quota Question, U.S. Government Printing Office, Washington, D.C., 1971.

Central Intelligence Agency, *International Oil Developments*, Statistical Survey, Office of Economic Research, December 4, 1975.

Chapel, Stephen W., *The Oil Entitlements Program and Its Effects on the Domestic Refining Industry*, The Rand Corporation, P-5717, September 1976.

Council on International Economic Policy, *International Economic Report of the President*, U.S. Government Printing Office, Washington, D.C., 1975.

Cowan, Edward, "Mandatory Fuel Allocation to Begin Today in Nation," *New York Times*, November 1, 1973.

Dam, Kenneth W., "Implementation of Import Quotas: The Case of Oil," *Journal of Law and Economics*, Vol. 14, No. 1, April 1971.

Duchesneau, Thomas D., *Competition in the U.S. Energy Industry*, Ballinger Publishing Company, Cambridge, Mass., 1975.

Federal Energy Administration, *Monthly Energy Review*, U.S. Government Printing Office, Washington, D.C., June 1976.

"Federal Regulations," *Federal Register*, Title 10, Chapter II, Parts 205, 210, 211, 212, and 213, U.S. Government Printing Office, Washington, D.C., 1975.

Federal Reserve Board, *Federal Reserve Bulletin*, U.S. Government Printing Office, Washington, D.C., various issues, 1974-1976.

First National City Bank, *Energy Memo*, Vol. 9, No. 2, New York, April 1973.

Friedman, Milton, "Two Economic Fallacies," *Newsweek*, May 12, 1975a.

Friedman, Milton, "Subsidizing OPEC Oil," *Newsweek*, June 23, 1975b.

Friedman, Milton, "Who Opposes Oil Decontrol?" *Newsweek*, September 15, 1975c.

Harberger, Arnold, *Taxation and Welfare*, Brown, Little & Company, Boston, 1974.

Helbling, Hans H., and James E. Turley, "Oil Price Controls: A Counter-Productive Effort," *Federal Reserve Bank of St. Louis Report*, Vol. 57, No. 11, November 1975.

Heller, Robert, *International Monetary Economics*, Prentice-Hall, New York, 1974.

Hicks, Sir J. R., *Value and Capital: An Enquiry into Some Fundamental Principles of Economic Theory*, Oxford University Press, 1939.

Jones, Ronald, "The Structure of Simple General Equilibrium Models," *Journal of Political Economy*, Vol. 73, No. 6, December 1965.

Kennedy, Michael, "An Economic Model of the World Oil Market," *The Bell Journal of Economics*, Vol. 5, No. 2, Autumn 1974.

New York Times, "House Vote Keeps Curb on Crude Oil," October 17, 1973.

Organization for Economic Cooperation and Development, *Main Economic Indicators*, Organization for Economic Cooperation and Development, Paris, 1976.

Owens, Charles R., "History of Petroleum Price Controls," *Historical Working Papers August 15, 1971, to April 30, 1974*, Office of Economic Stabilization, U.S. Dept. of the Treasury, U.S. Government Printing Office, Washington, D.C., 1974.

Pick Publishing Corporation, *Pick's Currency Yearbook*, New York, 1976.

Razin, Assaf, "A Note on the Elasticity of Derived Demand Under Decreasing Returns," *American Economic Review*, Vol. 64, No. 4, September 1974.

Stigler, George, and John Kendahl, *The Behavior of Industrial Prices*, Columbia University Press, New York, 1970.

U.S. Department of the Interior, *Federal and Indian Lands, Oil and Gas Production, Royalty Income, and Related Statistics*, U.S. Government Printing Office, Washington, D.C., June 1975.

U.S. Senate Committee on Interior and Insular Affairs, *Emergency Petroleum Allocation Extension Act of 1975*, Report No. 94-220, June 6, 1975, U.S. Government Printing Office, Washington, D.C., 1975a.

U.S. Senate Committee on Interior and Insular Affairs, *Oil Price Decontrol Hearings--First Session on the Competitive and Economic Impacts of Permitting the Decontrol of Petroleum Price and the Termination of Allocation Authority, September 4 and 5, 1975*, Serial No. 94-23 (92-113), U.S. Government Printing Office, Washington, D.C., 1975b.