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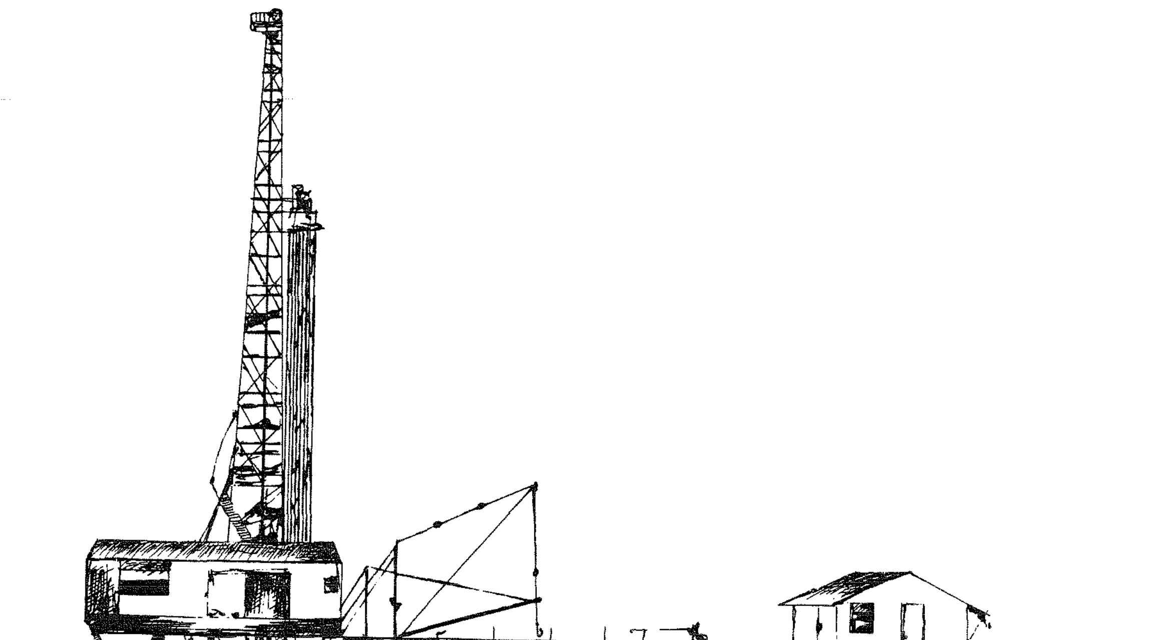

WINDFALL PROFITS, INTEREST RATES AND INDEX NUMBERS

Crude Oil Price Controls and the Windfall Profit Tax: Deterrents to Production?

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Throughout the decade of the 1970's, a complex system of Federal controls governed prices for domestically-produced crude oil. Those controls held the average price of domestically-produced crude below the world market level. Consequently, controls tended to reduce production substantially below the level that would otherwise have prevailed, aggravating a decade-long downtrend in U.S. crude-oil production.

For any given level of refiners' crude-oil demand, the reduction in domestic production raised imported-oil requirements by an equivalent amount. Moreover, that added import volume involved greater resource costs than would have been required through domestic production. As a result, controls worked against the nation's goal of energy independence and led to an inefficient allocation of resources.

Despite President Reagan's January 1981 lifting of controls on domestically-produced crude, producers still are not realizing the world price. The Windfall Profit Tax — which went into effect March 1, 1980 and could extend through 1990 — has been returning to the Federal government much of the added revenue that otherwise would have accrued to producers through decontrol. With the tax, producers are realizing less than the world market price, although of course more than they would have realized with continued controls. Thus, with the tax, future domestic production will be lower than it otherwise would have been with decontrol and no tax, although higher than with continued controls. Similarly, imports will be higher than otherwise, and the misallocation of resources will continue.

Section I presents a simple model of the supply of domestically-produced crude oil which shows how supply responds positively to prices received by producers. It also shows that, in the absence of controls, domestic crude oil would sell at approximately the world price because domestic producers operate in a world market. Section II describes the major features of the crude-oil price-control program contained in the recently terminated Energy Policy and Conservation Act of 1975. That section shows how that program held the average domestic price below the world market price, and thus kept domestic output below the amount that would have been produced in a free market. Section III outlines the major provisions of the Crude Oil Windfall Profit Tax of 1980. It shows how the tax leaves the price realized by producers still below the world price, reducing the positive impact of decontrol on domestic crude-oil production. Finally, Section IV presents a range of estimates of the domestic production losses that resulted from the Energy Policy and Conservation Act, and that potentially could result over the next decade from the Windfall Profit Tax. The recently-passed Reagan tax program contains minor changes in the windfall-profit tax, but these do not materially affect the conclusions of this paper.

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I. Domestic Oil Production in a Free Market

Domestic crude-oil production can be increased over the long-run in a number of ways, all of which are encouraged by a rise in selling price. "Long-run" means a planning period long enough to permit producers to invest in new productive capacity to achieve higher production rates. In crude-oil production, new productive capacity can be installed either at existing (i.e., already-producing) properties or at entirely new sites.[1]

At existing properties, producers can increase the rate of extraction by drilling more development wells. Alternatively, they can invest in enhanced oil-recovery technologies. This involves drilling service wells through which steam, chemicals, or gases may be injected to increase well pressure, thus raising the recoverable proportion of the total reservoir.

In addition, producers can expand production through the discovery of new properties — reservoirs in unproven regions as well as near already-producing areas. But first, producers must do some exploratory drilling and identify resources that are recoverable under current economic and technological conditions.

The addition of development wells at known reservoirs permits a higher rate of extraction from a given deposit, but it does not increase the ultimate, or total cumulative, production potential.[2] This potential can be expanded only through an increase in proved reserves, resulting from investments in enhanced oil-recovery technologies and the discovery of new economic resources. "Proved reserves" refer to the portion of the resource base that has been identified and explored, and from which crude oil can be recovered profitably at current prices and with current technology.[3] While the occurrence of oil is finite, being governed by geology, a host of other factors — economic, technological, environmental and political — determine the rate at which oil resources are discovered, developed and transferred to the category of reserves.

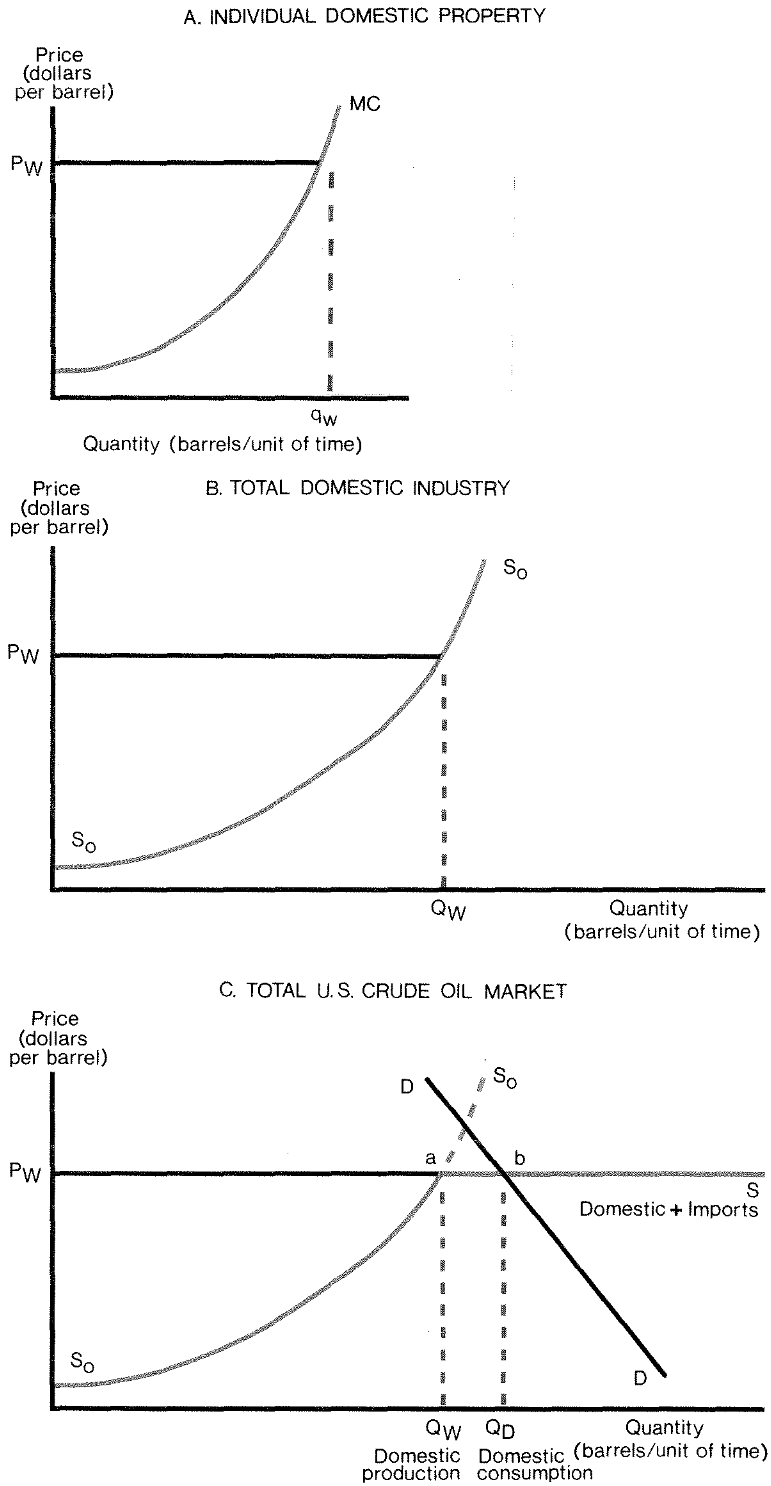
Long-run Supply Model

Building upon this foundation, we can further clarify the concept of the long-run supply schedule for representative individual properties, the domestic crude-oil producing industry and the combined domestic and import sectors through Charts 1A-C. The charts show, at a particular period in time, the quantity of crude oil that will be available to the U.S. market from those various sources at various selling prices. We assume, throughout the analysis, that the crude-oil producing industry is workably competitive, in line with the bulk of the evidence presented in the recent academic literature. With regard to structure, the producing and refining sectors of the industry are clearly different. Thousands of U.S. firms are engaged in the exploration and extraction of crude oil, with no firm dominant — in contrast to the oligopolistic refining sector of the industry.[4]

Chart 1A shows the long-run supply schedule for the representative individual property. This is the long-run marginal cost curve (MC) — the addition to total cost resulting from the last unit of output. The marginal cost of producing additional barrels from a given reservoir increases because firms must invest in higher-cost recovery techniques, such as enhanced oil-recovery methods and deeper development wells, as more oil is extracted from a finite reservoir. In a competitive market, each firm maximizes profit by expanding output to the point where marginal cost equals price. The schedule is upward sloping; as the price rises, it pays firms to produce the higher-cost barrels that would have been uneconomic to produce at a lower price.

Chart 1B shows the long-run supply schedule, S_0S_0, for the entire domestic crude-oil producing industry. That schedule is derived by summing the amounts produced by all properties at each price — that is, summing horizontally the marginal cost-output curves for all producing properties. Again, the schedule is upward sloping because, with

Chart 1
United States Crude Oil Supply Without Controls



increased production, firms must locate, develop and extract oil from less accessible and poorer quality resources.[5]

Chart 1C shows the long-run supply schedule for domestic and foreign oil available to U.S. refiners at various selling prices. At prices below the world price, P_W, the supply comes entirely from domestic sources. The price cannot exceed P_W, since imports are available essentially without limit at that price. Hence, the total supply schedule is represented by the kinked curve, S_0aS. Schedule DD meanwhile represents U.S. refiners' crude-oil demand schedule. In the absence of price controls, domestic crude oil would sell at approximately the world price, P_W — the landed price for imported oil.[6] This is because U.S. producers operate in a world market. At the world price, domestic production cannot meet the total quantity demanded by U.S. refiners. The price of imported crude thus represents the marginal cost of an additional barrel — and thus determines the marginal domestic producer price. At the world price — the domestic price that would prevail without controls — domestic producers would be willing to supply Q_W barrels. Domestic demand would be Q_D, and imports in the amount of Q_D-Q_W would be required.

Efficiency in the allocation of resources requires that the total cost of satisfying any given quantity demanded be as low as possible.[7] When the alternative to domestic oil is imported oil purchased at the world price, efficiency requires that production from all domestic properties be expanded to the point where the marginal cost of the last unit of output is equal to the price of imported oil. Beyond that point, resources could be saved by reducing domestic output and replacing that output with imported oil. But below that point, where the cost of the last barrel produced is less than the price of imported oil, resources could be saved by reducing imports and expanding domestic production.

Since the supply schedule S_0S_0 reflects the marginal cost of producing domestic oil, the uncontrolled market solution for domestic and foreign supply, S_0aS, represents an efficient allocation of resources. In this allocation, the marginal cost of production for all domestic producers is equal to the world price. There is no opportunity to reduce total cost by shifting supply between domestic and foreign sources.

II. Domestic Oil Production Under Price Controls

The Federal price-control programs of the 1970's held the average selling price of domestically-produced crude below the world market price, and thereby disturbed the efficient free-market solution. But government attempts to influence domestic prices first developed in the 1930's — although their purpose was to hold the producer price above (rather than below) the competitive level. During the 1930's, oil producing states instituted "conservation" programs — ostensibly to prevent "wasteful" production practices, but in reality, to keep prices high by limiting production.[8] Those programs were effective until the mid-1950's, when increasing quantities of foreign oil became available at prices well below the average domestic producer price. After trying (unsuccessfully) to restrict imports voluntarily, the Federal government in 1959 introduced a program of mandatory import quotas, using national security as justification.

The early 1970's witnessed a fundamental change in the nation's demand for imports. Despite the quota system, domestic crude-oil production peaked by 1970, as import competition prevented the domestic price from rising as fast as production costs. By 1973, U.S. petroleum consumption had outgrown domestic production, and imported oil had become the required source of marginal supplies. The marginal cost of imported oil, i.e., the world price, thus became the determinant of the domestic producer price.

Energy Policy and Conservation Act

The Federal government first placed direct controls on prices of domestic crude oil on August 15, 1971, when President Nixon froze wages and prices throughout the economy.[9] A multi-tier pricing system evolved in Phase IV of the controls program, announced in August 1973, and in the Emergency Petroleum Allocation Act, passed in November 1973 during the Arab oil embargo. These then led to the Energy Policy and Conservation Act of 1975 (EPCA). That legislation controlled domestic producer selling prices on a property-by-property basis, with production above and below the "base production control level" (BPCL) —the 1975 average monthly production — subject to different price ceilings. Under the act, "lower-tier" oil referred to output at or below the BPCL, while "upper-tier" oil referred to output in excess of this base level or output from new properties brought into production after 1975.

The law stipulated a lower price ceiling for lower-tier oil than for upper-tier oil, and stipulated that ceilings would be set to achieve a target average price for domestic oil. That price could rise to reflect inflation, but by no more than 10 percent annually.[10] Initially, the law classified oil from "stripper" properties — those producing ten barrels or less daily — as upper-tier oil. But in September 1976, the energy agency decontrolled stripper oil and thus permitted it to receive the world market price.

Policymakers designed the control program to hold the average price of domestically-produced crude below the world market level, and thereby protect consumers from the full impact of sharply rising world prices — in effect, transfering to consumers much of the added income that would otherwise have accrued to producers.[11] At the same time, policymakers sought, through the multi-tier system, to accomplish that objective with the least possible reduction in production incentives. Since decisions to expand production are determined on the margin, they permitted production in excess of the base level to receive a higher ceiling price. In that way, they hoped to provide sufficient incentive to stimulate production. But they also wanted to prevent owners of wells brought into production before the OPEC price run-up from receiving profits far higher than originally anticipated and so held the lower-tier price not only below the world level but the upper-tier price. In this view, the removal of such unanticipated profits — "windfalls" — would have little impact on production decisions. (A similar philosophy apparently underlies the new Windfall Profit Tax.) Nevertheless, because controls generally held the price at the margin below the world price, production was less than it otherwise would have been.

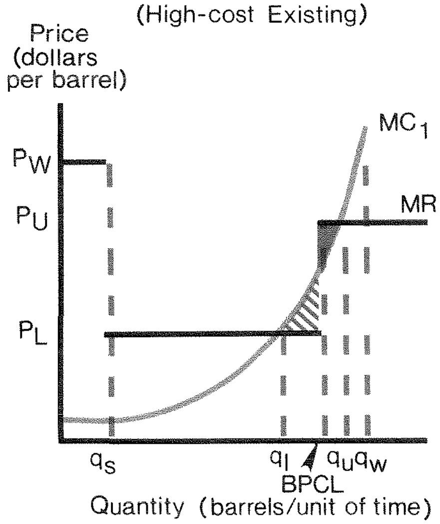
Charts 2A-C illustrate the price and production effects of the Energy Policy and Conservation Act for representative properties and the entire domestic industry.[12] Properties in existence before 1975 faced the marginal revenue (MR) schedule shown in Chart 2A. Output of q_s or less qualified as stripper oil and received the uncontrolled (world) price, P_W. Output from q_s to the base production control level (BPCL) received the lower-tier price, P_L. Output in excess of BPCL received the upper-tier price, P_U. "New" properties — those brought into production after 1975 — faced the marginal revenue schedule shown in Chart 2B, and except for small stripper properties, received the upper-tier price.

Existing stripper properties were unaffected by this system of price controls. Those properties received the world price, with or without controls, and hence production remained the same at q_s. But for other existing properties, production was lower than it would have been without controls, since production was not permitted to receive the world price. The magnitude of the impact depended on whether costs had risen since the 1975 base year.

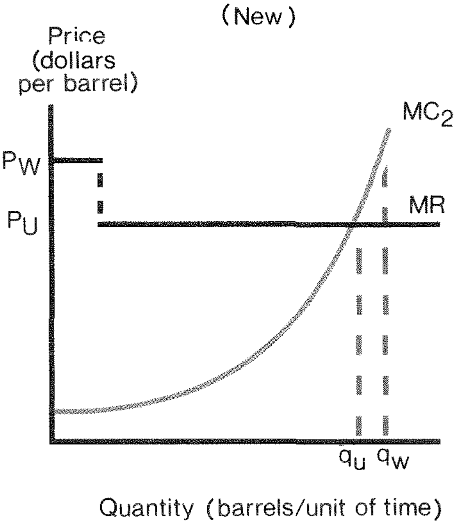
Producers not incurring higher costs would have found it profitable to expand production past the base-period level, to earn the upper-tier price on the new production. Production

Chart 2
United States Crude Oil Supply Under Energy Policy and Conservation Act

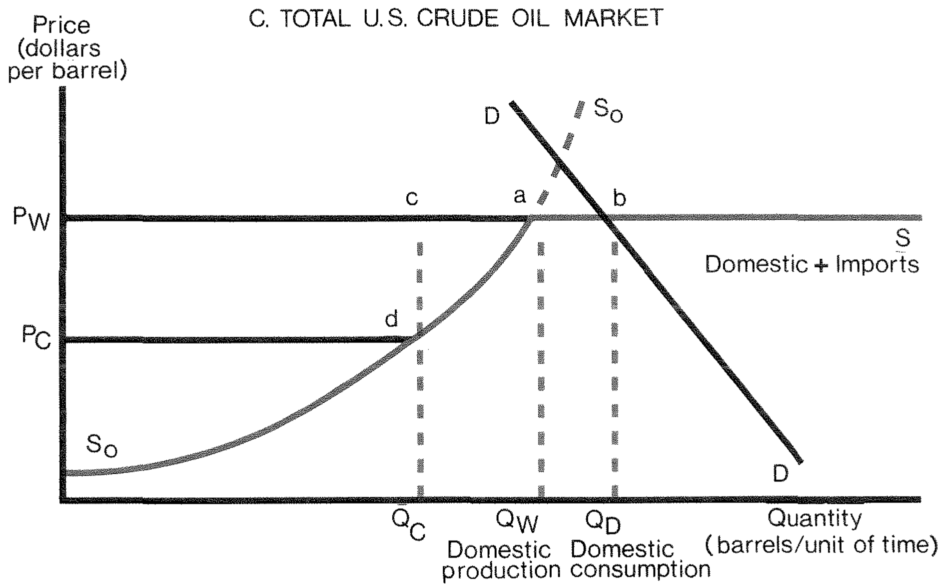
A. INDIVIDUAL DOMESTIC PROPERTY (High-cost Existing)



B. INDIVIDUAL DOMESTIC PROPERTY (New)



C. TOTAL U.S. CRUDE OIL MARKET



still would have been lower than it would have been without controls, however, since the upper-tier price was below P_W. Producers incurring higher costs than faced in 1975 would have fared less well. (See the marginal cost schedule, MC_1, in Chart 2A.) For those properties, producers would not have found it profitable to expand production beyond the base-period level. The new production up to the base level would earn only P_L, the lower-tier price, which would be below the cost of producing it. The profit earned on upper-tier oil (shaded area) would not cover the loss incurred on lower-tier oil (striped area) and the firm would choose to remain producing at q_1. Producers incurring an extremely sharp rise in costs since 1975 would have an incentive to actually lower production to 10 barrels or less per day, to qualify for the uncontrolled price afforded stripper properties.

Producers with new properties would have found less incentive to produce than in a situation with no controls (Chart 2B). When the world price was P_W, output from new properties was only q_u because they were permitted to receive only the price P_U. Had price controls not existed, output on new properties would have been q_w, because that output would have received the world price.

At the industry level, this system of controls, like its predecessors, tended to hold the average domestic producer price below the world market level, thereby reducing production below the level that would otherwise have prevailed (Chart 2C). When the world price is P_W, controls hold the average domestic producer price at P_C. As a result, the domestic industry produces only Q_C instead of the quantity Q_W produced in the absence of controls. For a given level of refinery crude oil demand, the consequent reduction in domestic output is offset entirely by imports. Thus the control program tended to increase the nation's dependence on foreign oil.

The control program also led to inefficiency in the allocation of resources. Between output levels Q_C and Q_W, each additional barrel of crude could be produced domestically at a cost below the world price, and thus at a smaller expenditure of resources than for imported oil. Area dca, which equals the difference between the world price and the domestic supply schedule S_0S_0 at each increment between Q_C and Q_W, represents resources wasted on expenditures for imported oil because of controls.[13]

Intertemporal Production Decisions

Thus far, we have considered the effects of controls only in a static framework. We have assumed that firms consider only the current price, without regard to price expectations, when making production decisions. Also, we have ignored the potential effects of the current level of output on future production. We have assumed that firms could obtain optimal production and profit paths over time by producing at the point where marginal cost equals price in each planning period.

But there is an important difference between the marginal-cost (supply) schedule of a typical manufacturing firm and the schedule of a firm extracting an exhaustible resource such as petroleum. As petroleum is removed from a reservoir, the pressure of the reservoir declines, and so too does the total amount of petroleum available — a tendency known as the "natural decline function." Because of the exhaustible nature of the resource, a barrel of oil produced today will not be available in some future period. Petroleum producers thus face an additional cost of production not incurred by manufacturers. That additional cost — the user cost — is the opportunity cost or profit foregone of being unable to sell that unit of output in the future.

In order for a producer to decide to produce a barrel of oil in the present, the price of each additional barrel of oil produced today must be sufficient to cover this opportunity cost as well as normal production costs. Moreover, in view of the effect of current output on future output — the "natural decline" problem — the firm cannot simply select the output level in each period where marginal revenue equals marginal cost (defined to include user cost). Instead, the firm must maximize a stream of profits over time, which involves a discounting procedure. This present-value analysis, in effect, states that for production of an additional barrel to take place, the present profit invested at the market rate of interest must at least be equal to the profit from selling that barrel any time in the future.[14]

By affecting price expectations, the controls program may have exerted still another restraining effect on current production. If the expected path of future prices rises, the user cost increases and producers can expand profits by deferring current production to the future. In this case, the present value of the future profit would exceed today's profit. Controls on current prices may have created just such an expectation of higher prices in the future when controls eventually might be lifted. The expected price path in moving from control to decontrol would have been steeper than had prices never been subject to controls. As a result, controls may have raised the user cost of controlled oil, thereby causing producers to restrict current production even more than they would have done because of receiving less than the world-market price. This was especially true of the 1978-80 period, when market participants widely expected eventual decontrol.[15]

III. Domestic Oil Production Under "Decontrol"

On June 1, 1979, the Energy Department began to implement a program, mandated by President Carter, for decontrolling domestic crude-oil prices by October 1, 1981. Under that program, production that previously would have been subject to the lower-tier price was permitted to move gradually to the upper-tier category. Then, beginning on January 1, 1980, production previously classified as upper-tier oil, plus the lower-tier oil moving into the upper-tier category, was permitted to move to a free-market classification at a rate of 4.6 percent per month.

The Energy Department decontrolled oil discovered after January 1, 1979 on June 1 of that year, and it lifted controls on "heavy" crude on August 17, 1979. Finally, the Reagan Administration — in its first major economic-policy move — lifted all remaining price controls on domestically produced crude on January 28, 1981.

In moving to decontrol domestic prices, both the Carter and Reagan Administrations hoped to encourage domestic production and to slow down the growth of U.S. petroleum consumption. To the extent that the higher refiner costs for domestic crude were reflected in higher refined-product prices, consumption should be curtailed.[16]

Windfall Profit Tax

At the same time, Congress was unwilling to permit producers to realize all the added revenue that would accrue through decontrol, especially since that step could boost producer revenues by about $1 trillion over the 1980-90 period, according to estimates of the Joint Committee on Taxation.[17] As a result, Congress enacted the Crude Oil Windfall Profit Tax of 1980 to divert to the U.S. Treasury some of the incremental revenues that would otherwise be received by producers through decontrol. The tax became effective March 1, 1980.

The tax is perhaps the largest ever imposed on a single industry. Over the 1980-90 period, the tax could yield about $236 billion, in addition to a $332-billion increase in corporate income taxes resulting from decontrol. Thus, the U.S. Treasury could receive $568 billion of the projected $1-trillion additional industry revenue received from decontrol.[18]

Although called a tax on profit, the tax really is a Federal excise tax on a portion of the selling price received from crude oil. The tax paid per barrel is determined by applying various tax rates to the "windfall profit" — the difference between the decontrolled producer price and the price that would have prevailed under continued controls (less state severance tax).

The tax rates and base prices applicable to various properties vary according to type of production and size of producer (Table 1). The Internal Revenue Service established these new oil categories for tax purposes. Producers are classified either as "majors" or as "independents" (producers with gross annual sales of $5 million or less and with refining capacities of no more than 50,000 barrels a day). Identical tax rates are applied, except for the first 1,000 barrels a day of Tier 1 and Tier 2 production by independents. To provide greater incentive for certain investments, the lowest tax rates apply to newly discovered and incremental tertiary oil, the latter being oil obtained through a qualified tertiary (enhanced) recovery method, i.e., production in excess of the projected decline rate for the property without the tertiary technique.[19]

In computing the tax, producers first subtract a base price, adjusted for inflation, from the decontrolled producer price (Appendix A). Next they subtract a state severance tax — estimated to average about 5.4 percent of the selling price — to determine the "windfall profit." Then they apply the appropriate tax rate to determine the amount of tax to be paid.

Table 1
Provisions of the Windfall Profit Tax[1]

	Tax Rate			
	Integrated Producer	Independent Producer[3]	Base Price	Annual Adjustment to Base Price
	(percent)		($ per bbl.)	(percent)
Tier 1				
Controlled oil discovered before 1979[2]	70	50	12.81	Inflation[6]
Tier 2				
Stripper well oil	60	30	15.20	Inflation
National Petroleum reserve oil	60	30	15.20	Inflation
Tier 3				
Newly discovered oil	30	30	16.55	Inflation + 2%
Heavy oil	30	30	16.55	Inflation + 2%
Incremental tertiary oil[4]	30	30	16.55	Inflation + 2%
Exempt[5]				

[1] The Windfall Profit Tax of 1980 was enacted into law on April 2, 1980. But the tax was retroactive, i.e., applicable to crude-oil production removed from properties after February 29, 1980.

[2] For purposes of the windfall-profit tax, the pricing categories conform to those in effect in May 1979, before the process of gradual decontrol began.

[3] The special reduced-tax rates afforded independent producers for Tiers 1 and 2 are applicable only to their first 1,000 barrels per day of production. Production in excess of 1,000 b/d is taxed at the regular windfall-profit tax rates, i.e., the rates applicable to integrated producers.

[4] Incremental tertiary oil is the amount of production from a property on which a producer uses a qualified tertiary (enhanced) recovery method in excess of the projected decline rate if a tertiary technique had not been used on that property.

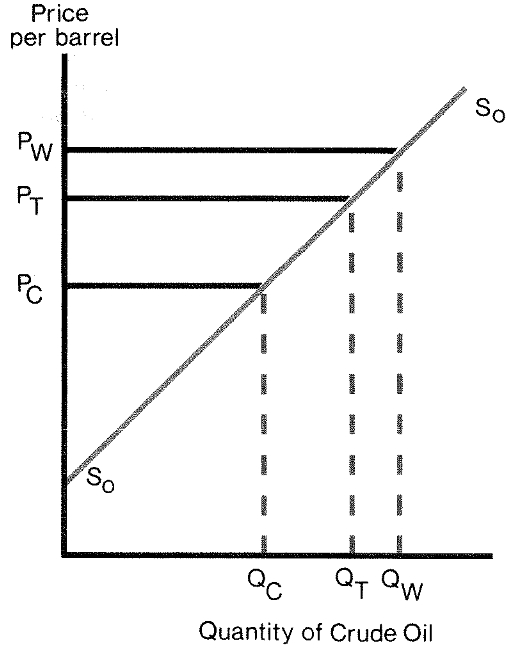
[5] Categories of crude exempt from the tax include: qualified governmental-interest oil, qualified charitable-interest oil, certain Indian oil, Alaskan oil (other than from the Sadlerochit reservoir) north of the Alaska-Aleutian mountain range and over 75 miles from the pipeline, and tertiary oil from properties owned by independent producers.

[6] Inflation is measured by the change in the Gross National Product deflator.

Chart 3 shows how the windfall-profit tax will affect U.S. crude oil production as long as the uncontrolled domestic price remains above the adjusted base price.[20] $S_0 S_0$ represents the long-run supply schedule for the domestic crude-oil producing industry. Decontrol with no tax would provide producers with the maximum incentive to increase production, and would lead to an efficient allocation of resources in meeting with the nation's petroleum requirements. In this situation, producers would realize the uncontrolled price, P_W, and produce at output Q_W. With continued controls, producers would realize price, P_C, and supply Q_C. The tax lowers the price realized by producers below the free-market price to an intermediate price, P_T. Since the uncontrolled domestic selling price is determined by the world price, producers must absorb the tax as a reduction in realized price, and cannot pass it on to consumers. The tax thus reduces the incentive to increase production provided by decontrol. At price, P_T, quantity Q_T is produced — more than would be produced with continued controls but less than would be produced with decontrol and no tax. Production is greater than with continued controls because only part of the so-called "windfall" is diverted to the U.S. Treasury.

Chart 3

Effects of Windfall Profit Tax on Domestic Crude Oil Production



IV. Estimating Production Losses

Crude-oil production in the United States dropped 10 percent over the 1970-79 period, and would have dropped 24 percent except for the addition of 1.4 million barrels per day of Alaskan North Slope production. The decade-long decline in production resulted inevitably from a decline in the amount of oil added to reserves annually, through new discoveries and enhanced oil recovery, during the 1970-79 period compared with the decade of the 1960's. Unless gross annual additions to reserves exceed the rate of extraction, the total inventory of proved reserves declines. Producers were forced to lower production so as not to experience an even greater run-down in their proved reserve inventory. Even with a cutback in production, proved reserves — the industry's working "in the ground" inventory — declined steadily over the 1970-79 period from 39.0 to 27.1 billion barrels.

Even with controls, the average wellhead price for domestically-produced crude rose three-fold over the 1973-79 period (Table 2). This price upsurge led to a reversal of the prolonged decline in exploration activity that had occurred over the preceding decade and a half. Between 1973 and 1979, the total number of oil wells drilled nearly doubled, rising at an average annual rate of 16 percent.

Nonetheless, additions to reserves still dropped from an average annual rate of 2.7 billion barrels during the 1965-69 period to 2.0

billion barrels during the 1971-74 period, and then to only 1.3 billion barrels during the 1975-78 period. The rate of reserve additions only began to pick up, to 2.2 billion barrels, with a new price upsurge during the period of gradual decontrol in 1979.

Without price controls, drilling activity would have increased somewhat faster, raising annual additions to reserves as well as production at existing properties through development drilling. How much did the controls — more specifically the Energy Policy and Conservation Act — contribute to the decline in production?

Energy Policy and Conservation Act

To answer that question, we could develop a petroleum-supply model to project production under an uncontrolled price assumption. Then, that outcome could be compared with actual production to estimate production losses. Given the fact that the oil-supply process involves several phases — exploration, reservoir development, and production — the development of such a model would be a vast

Table 2
Relationship Between Controlled Domestic Crude Oil Prices and World Price, 1972-80

Year	Average Refiner Acquisition Price Imported Crude[1]	Average Domestic Price at Wellhead Without Controls (est.)	With Controls						Average Domestic Price: Controlled as Percent of Uncontrolled
1972	3.22	3.39[2]	3.39						100.0
1973	4.08	3.89[2]	3.89						100.0
				Old Oil[4]	New Oil[5]				
1974	12.52	11.66[3]	6.87	5.03	10.13				58.9
1975	13.93	12.95[3]	7.67	5.03	12.03				59.2
				Lower-Tier	Upper-Tier	Stripper			
1976	13.48	12.56[3]	8.19	5.13	11.71	12.16			65.2
							Alaska North Slope	Naval Petroleum Reserves	
1977	14.53	13.59[6]	8.57	5.19	11.22	13.59	6.35	12.34	63.1
1978	14.57	13.95[6]	9.00	5.46	12.15	13.95	5.22	12.85	64.5
1979	21.67	22.93[6]	12.64	5.95	13.20	22.93	10.57	19.40	55.1
1980	33.82	35.54[6]	21.20	6.49	14.34	35.54	14.14	33.06	59.6

[1] Before entitlement benefit.

[2] In 1972 and most of 1973, petroleum prices were subject to the Phase I-IV price provisions of the Economic Stabilization Act. The average domestic wellhead price during that period did not differ substantially from the refiner acquisition cost of crude, so it can be assumed that controls had little effect on domestic crude-oil prices. As a result, prices are assumed to be the same with or without controls.

[3] Estimated by excluding domestic producers' transportation costs from the refiner acquisition price for imported oil, the adjustment being based on the post-1976 price of stripper oil. This adjustment reflects the fact that the wellhead price for stripper oil—decontrolled in September 1976—represents an uncontrolled price for domestic oil exclusive of transportation costs.

[4] Under the Emergency Petroleum Allocation Act in effect throughout 1974 and 1975, "old" oil in any given month was defined as the quantity produced from a given property in the corresponding month of 1972.

[5] Under the Emergency Petroleum Allocation Act, "new" oil was defined as any production in excess of output in the same month of 1972.

[6] The post-1976 (decontrolled) stripper price was used as a proxy for the uncontrolled domestic producer price. Actually, in 1979 and 1980, stripper oil sold at a substantial premium above comparable-quality imported oil, due to tight worldwide supply conditions and the willingness of refiners to pay a premium for security of supply.

Source: Uncontrolled domestic price at the wellhead estimated by author as described in footnote 3 above. Actual prices as published by U.S. Department of Energy, *Monthly Energy Review*.

undertaking. Instead, we have relied upon already existing models to obtain long-run price elasticities of supply upon which to estimate the production losses resulting from that particular control program. Elasticity of supply is a measure of the responsiveness of the quantity supplied of a given product to an increase in its price.

In the absence of controls, the average wellhead prices of lower and upper-tier crude oil would have risen from their respective controlled levels to the world market level.[21] At existing properties — those in operation before 1975 — an increase in prices would have: (1) raised investment in development wells, thereby raising the rate of extraction from proved reserves and (2) encouraged greater investment in enhanced oil-recovery methods, thereby increasing additions to reserves through improved technology. An increase in the upper-tier price also would have encouraged more exploratory drilling, leading to the discovery of more new reserves at new properties.

This study attempts to estimate how much extra production would have been forthcoming had prices been allowed to rise to the world price. It does so by drawing on outside estimates of the elasticity of supply, the percentage change in quantity supplied divided by the percentage change in price. In estimating production losses as a result of controls, we calculated the percentage difference between the uncontrolled and controlled prices in any given year, multiplied that by the supply elasticity to get the percentage change in output, and then converted that percentage change to an arithmetic change by multiplying it by the existing quantity.

Recent studies by the Department of Energy suggest a long-run price elasticity of about .2 for categories of production equivalent to "existing properties."[22] Numerous econometric studies are available for deriving elasticity estimates for new properties. These studies relate price to additions to reserves from new discoveries. The authors then assume that a given increase in new reserves leads to an equivalent percentage increase in production, as we also have done here.[23] These studies have yielded a wide range of elasticity estimates — ranging from .3 to .8 — with the variation perhaps due in part to the different time periods involved.[24]

Utilizing these published elasticity estimates, we estimated production losses for the 1976-79 price-control period under several different elasticity assumptions (Table 3). The elasticity of production from *existing* properties was assumed to be .2 in each scenario. However, the elasticities of production from *new* properties ranged from .3 (low), to .5 (medium) to .8 (high assumption).

All these elasticity estimates pertain to the long-run. They show how production eventually might respond to a given change in price after time had elapsed for exploration and development. In our estimates, however, we have recorded the response as if it shows up fully within a year. For example, the estimated production losses for 1976 represent the additional production that would be forthcoming in the long-run as a result of closing the differentials between controlled and uncontrolled prices prevailing during that year. Although recorded for that single year, in reality the production response would take considerably longer.

The results indicate a substantial lowering of production by controls in the 1976-79 period, under all scenarios (Table 3). The likeliest outcome would probably arise from the low-response assumption, because elasticity of supply would surely fall in the wake of a substantial widening of price differentials. Under this low-response scenario, production with uncontrolled prices eventually could have been 10 percent higher in 1976, and 29 percent higher in 1979, than actual production with controlled prices. The comparable production increases under the high-response scenario would have been 15 percent in 1976 and 73 percent in 1979 — although the underlying elasticity estimates in that scenario appear to be unrealistically high. The limited nature of the resource base, and the further depletion in recent years, would preclude the likelihood of very high supply elasticities — .8 for new dis-

Table 3
Domestic Crude Oil Production Losses Under the Energy Policy and Conservation Act, 1976-79
(Production in millions of barrels)

	Domestic Crude Oil Prices[1] (Dollars per barrel)			Domestic Crude Oil Production (Millions of barrels)
	Prices with Controls			
Year	Lower-Tier	Upper-Tier	Estimated Price Without Controls[2]	Total Production With Controls
1976	5.13	11.71	12.56	2968
1977	5.19	11.22	13.59	3009
1978	5.46	12.15	13.95	3178
1979	5.95	13.20	22.93	3115

Domestic Crude Oil Production (Millions of barrels)

Low Response	Estimated Production Losses Due to Controls[3]			
Year	Existing Properties[4]	New Properties[4]	Estimated Total Production Without Controls	Additional Domestic Production Without Controls as a Percent of Production with Controls
1976	267	18	3253	9.6
1977	277	141	3427	13.9
1978	228	89	3495	10.0
1979	350	561	4026'	29.2
Medium Response				
Year				
1976	267	115	3350	12.9
1977	277	330	3616	20.2
1978	228	244	3649	14.8
1979	350	1102	4566	46.6
High Response				
Year				
1976	267	187	3421	15.3
1977	277	544	3830	27.3
1978	228	398	3804	19.7
1979	350	1924	5389	73.0

[1] Annual averages; producer prices at the wellhead.

[2] For an explanation of the derivation of this price series, see Table 2.

[3] Derived by the author on the basis of three separate assumptions regarding price elasticity of supply for new properties. Each response is assumed to become fully effective within a single year, although in reality, the production response to closing any given differential between controlled and uncontrolled prices would take more than a year.

[4] Elasticity figures for existing properties are .2 in all cases; for new properties .3 for low response, .5 for medium response, and .8 for high response.

Source: Price and actual production data: U.S. Department of Energy, *Monthly Energy Review.* Estimated production losses computed by author using methodology described in text.

coveries — included in that scenario.[25]

In all scenarios, the potential losses with controls would have been very large on the basis of 1979 prices because of the huge increase estimated for wellhead prices in the absence of controls. The average refiner acquisition price for imported crude (before entitlements) rose by only 4½ percent over the entire 1975-78 period, but then jumped 49 percent within 1979 alone (Table 2), as OPEC members sharply boosted prices in the wake of the cutoff of Iranian exports and consequent world-wide tightening of supplies. The average domestic wellhead price without controls — the average refiner acquisition price for imported crude less transportation costs from domestic wells to refineries — thus would have risen about 58 percent in 1979. Indeed, that wellhead price probably would have risen even more, because of refiners' willingness to pay a premium for domestic oil for security of supply. In this situation, controlled prices of lower-tier and upper-tier oil would have been only 17 and 39 percent, respectively, of the estimated uncontrolled price for domestic oil.

Windfall Profit Tax

The windfall profit tax will dilute the stimulus to increased production provided by decontrol. The amount of dilution will depend principally upon the future behavior of the uncontrolled domestic-producer selling price — and thus the after-tax realized price — and upon the production response to any given increase in realized price.

Based upon an assumed 2 percent "real" average annual increase in the uncontrolled domestic producer selling price over the 1980-90 period, we have developed different sets of estimates of the offsetting effect of the windfall-profit tax on the positive production response from decontrol for the years 1985 and 1990.[26] This involves the development of three alternative policy assumptions: (1) Scenario I, continued price controls; (2) Scenario II, decontrol with no windfall-profit tax, and (3) Scenario III, decontrol with a windfall-profit tax. As before, we have assumed a lower elasticity of supply for oil from existing properties — Tiers 1 and 2, as well as heavy oil and incremental tertiary oil —

Table 4
Estimated Domestic Producer Oil Prices, 1985 and 1990, Under Three Alternative Policy Assumptions[1]

	Scenario I			Scenario II	Scenario III		
Year	Prices with Continued Controls[2]			Prices with Decontrol but No Windfall Profit Tax[3]	Prices with Decontrol and Windfall Profit Tax[4]		
	Tier 1	Tier 2	Tier 3		Tier 1	Tier 2	Tier 3
1985	19.92	23.64	28.23	53.93	29.57	35.10	45.25
1990	26.78	31.77	41.92	79.84	41.84	49.96	67.03

[1] Annual averages in dollars per barrel; producer sales prices.

[2] For 1985 and 1990, prices with controls were estimated by making inflation adjustments to the base prices for each tier (as defined in the Crude Oil Windfall Profit Tax of 1980, Table 1). For 1980, the adjustment factors were based on the GNP deflator. Thereafter, the inflation rate was assumed to decline gradually, reaching a 6.0-percent annual rate by mid-1986 and remaining at that rate through 1990. For Tier 3, the base price was adjusted upward by an additional 2 percent each year, as allowed in the law.

[3] The author estimated that domestic oil, without controls, would have sold for $35/barrel in the fourth quarter of 1980. For 1985 and 1990, the decontrolled price was estimated by adjusting the 1980 price to reflect inflation plus an assumed 2-percent annual increase. The anticipated price of heavy oil in 1980 was assumed to be $7.50 less than the average domestic price, reflecting the traditional price differential.

[4] The author assumed that the windfall profit tax effectively reduces the selling price actually realized by domestic producers. For a description of the derivation of these prices, see Appendix A. The tiers represent the categories of domestic oil as defined by the Crude Oil Windfall Profit Tax of 1980, as shown in Table 1.

than for oil from newly discovered properties. And again, we have assumed a range of elasticities for Tier 3 newly-discovered oil, ranging from .3 (low), to .5 (medium) to .8 (high assumption).

To develop production estimates, we first estimate producer prices under each of the three scenarios (Table 4), making the estimates in nominal terms to conform with the actual computation of the windfall-profit tax. The tax affects production in any given period through its impact on the realized relative price of oil compared with what it would be without the tax.

Under continued controls (Scenario I), we calculate prices for Tier 1 and Tier 2 oil for the years 1985 and 1990 as equal to certain base prices (defined by the Windfall Profit Tax)

Table 5: Estimated Domestic Crude Oil Production, 1985

	Scenario I Production with Continued Price Controls[3]				Scenario II Production with Decontrol but No Windfall Profit Tax[4]			
Low Response[2]	**Tier 1**	**Tier 2**	**Tier 3**	**Total**[6]	**Tier 1**	**Tier 2**	**Tier 3**	**Total**[6]
1979 (Actual)	2,046	500	97	3,113	(.2)	(.2)	(.3)	
1985	730	536	907	2,748	891	632	1,530	3,628
1990	318	637	1,035	2,464	396	766	1,611	3,248
Medium Response[2]								
1979 (Actual)	2,046	500	97	3,113	(.2)	(.2)	(.5)	
1985	730	536	907	2,748	891	632	2,094	4,192
1990	318	637	1,035	2,464	396	766	2,112	3,749
High Response[2]								
1979 (Actual)	2,046	500	97	3,113	(.2)	(.2)	(.8)	
1985	730	536	907	2,748	891	632	2,993	5,091
1990	318	637	1,035	2,464	396	766	2,912	4,549

[1] In millions of barrels.

[2] Low, medium and high responses refer to the assumed elasticities of supply for various categories of crude. Tier 1 and Tier 2 oil, as well as heavy oil and incremental tertiary (enhanced) oil in Tier 3, were assumed to be oil from existing properties. Oil from new properties appears in Tier 3. In each response case, oil from existing properties (Tiers 1 and 2 and heavy oil and incremental tertiary oil in Tier 3) was assumed to have a price elasticity of .2. The elasticity for new properties (Tier 3) varied from .3 in the low case to .5 in the medium case and .8 in the high case.

[3] Assumes domestic oil prices behave as described in Table 4, Scenario I, with a continuation of the controls embodied in the Energy Policy and Conservation Act. Production estimates for the years 1985 and 1990 under this assumption are from the Congressional Budget Office study cited below, page 76. These production estimates were used to derive our Scenarios II and III.

[4] Assumes domestic oil prices behave as described in Table 4, Scenario II. Production was estimated on the basis of the same supply elasticities utilized in estimating producing losses under the Energy Policy and Conservation Act.

adjusted by inflation (measured by the GNP deflator). The Tier 3 inflation adjustment equals the inflation rate plus 2 percent annually, as specified in the law.[27] Thus, in this scenario, prices for Tier 1 and Tier 2 production remain constant in real terms, while the price for Tier 3 production rises at a 2-percent real annual rate. Under decontrol (Scenario II), we estimate the free market price by applying the inflation-plus-2-percent adjustment to the uncontrolled stripper price ($35 a barrel) in the fourth quarter of 1980. (We use the same methodology, although a higher base price, as the Joint Committee on Taxation uses in estimating windfall-profit tax revenue.)[28] Under decontrol and the tax (Scenario III) we calculate the realized producer price by adding the extra after-tax

and 1990, Under Three Alternative Policy Assumptions[1]

Percent Increase in Total Production Due to Decontrol[7]	Scenario III: Production with Decontrol and Windfall Profit Tax[5]				Percent Increase in Total Production After Tax[8]
	Tier 1	Tier 2	Tier 3	Total[6]	
	(.2)	(.2)	(.3)		
32.0	790	580	1,314	3,259	18.6
31.8	348	697	1,416	2,936	19.2
	(.2)	(.2)	(.5)		
52.5	790	580	1,690	3,635	32.3
52.2	348	697	1,752	3,272	32.8
	(.2)	(.2)	(.8)		
85.3	790	580	2,243	4,188	52.4
84.6	348	697	2,247	3,767	53.7

5 Assumes domestic oil prices behave as described in Table 4, Scenario III.

6 Alaskan oil from proved reserves has been included in the production totals, but not in any tier. The author estimated this Alaskan production at 575 and 475 million barrels in 1985 and 1990, respectively, compared with 471 million barrels in 1979.

7 This refers to the amount (percent) by which total production without controls (Scenario II) would exceed total production with continued controls (Scenario I) during the years 1985 and 1990, respectively.

8 This refers to the amount (percent) by which total production without price controls but with the windfall profits tax (Scenario III) would exceed total production with continued controls (Scenario I) during the years 1985 and 1990, respectively.

Source: Production estimates in Scenario I, Congressional Budget Office, *The Windfall Profits Tax: A Comparative Analysis of Two Bills*, 1979. All other estimates by the author.

revenue per barrel to the estimated price under continued controls (Appendix A).

With these assumptions, the nominal free market price rises from $35/barrel during 1980-IV to about $54/barrel by 1985 and $80/barrel by 1990 (Table 4). After-tax producer prices thus range (depending on tier) from 55 to 84 percent of the uncontrolled price by 1985, and from 52 to 84 percent of the uncontrolled price by 1990.

With these price estimates, and with Congressional Budget Office estimates of production under continued controls, we derive (Scenario II and III) production estimates by applying appropriate supply elasticities, just as we did in estimating the effects of the Energy Policy and Conservation Act.[29] The use of nominal prices to estimate production losses is justified by the use of the same inflation adjustment for both controlled and uncontrolled prices, so that inflation has a neutral effect.

As seen in Table 5, domestic oil production undoubtedly would have continued to trend downward over the 1979-90 period under continued price controls. But all three sets of assumed elasticities suggest that production is likely to rise substantially between 1979 and 1985 under decontrol. The Congressional Budget Office's forecast for production under continued controls shows total production dropping from 3,113 million barrels in 1979 to 2,748 million barrels by 1985, and then to 2,464 million barrels by 1990. Under the "low response" set of elasticities, total production with decontrol and no tax would reach 3,628 million barrels in 1985 and 3,248 million barrels in 1990. With the tax, production could still reach 3,255 million barrels in 1985 and 2,936 million barrels in 1990. Production figures in the "high response" case would be considerably higher, but as already indicated, the elasticity figures involved appear to be unrealistically high.

Here again, the production differentials between the scenarios would not necessarily occur specifically in 1985 and 1990. Rather, the differentials represent the ultimate production responses to the estimated price differentials existing in those years as a result of the tax.

Domestic production probably would rise

Table 6: Estimated Domestic
Under Three Alternative Domestic Oil Price

	Scenario I	Scenario II	
Annual Percent Increase in the Decontrolled Domestic Price in Real Terms	Total Production with Continued Controls[3]	Total Production With Decontrol but No Windfall Profit Tax	Percent Increase in Production With Decontrol but No Windfall Profit Tax
−2	2748	3790	37.9
0	2748	3962	44.2
+2	2748	4192	52.5
+5	2748	4555	65.8
+10	2748	5209	89.6

[1] Annual production in millions of barrels.

[2] Medium response assumes an elasticity of .2 for tiers 1 and 2, respectively, and also for heavy oil and incremental tertiary oil in tier 3. It assumes an elasticity of .5 for newly discovered oil in tier 3.

even faster than projected, under all three sets of elasticity assumptions, if the uncontrolled price rose at more than 2 percent above the inflation rate (Table 6). For example, in the medium-response situation, an increase from 2 percent to 5 percent in the real rate of oil-price rise would mean an increase, from 53 percent to 66 percent, in the production differential achieved by 1985 because of the shift from controlled to uncontrolled prices. With the windfall profit tax in effect, the production differential would be 32 percent with a 2-percent real increase in prices, and 41 percent with a 5-percent real rate of increase.

The higher prices being realized by producers as a result of decontrol apparently are now exerting a dramatic impact on exploration and development activity. Drilling activity set a new record in 1980, surpassing the previous highs reached in the mid-1950's. During the year, the industry drilled nearly 65,000 wells of all types — about 26 percent more than during 1979. For the year, total footage drilled rose 23 percent, while the number of drilling rigs in operation rose 32 percent. New records appear in prospect for 1981.

Unfortunately, increased drilling activity has not been translated into an increase in proved crude-oil reserves. In 1979, total reserves continued a decline that began in 1968. But gross additions to reserves amounted to 2.2 billion barrels, the highest figure since 1971. This meant a narrowing of the deficit between the gross volume added to reserves and the amount extracted. The inventory of proved reserves dropped by only 0.8 billion barrels — the smallest amount since 1968.

In any event, our analysis indicates that the windfall-profit tax would reduce the production response expected from decontrol. As a measure to reduce dependence on foreign-oil imports and improve the allocation of resources, decontrol is a step in the right direction. But by the same token, the windfall-profit tax is a step in the wrong direction. Perhaps policymakers should alter the tax to make it a true tax on profits rather than an excise tax on a portion of the selling price. In that way, it would not affect production decisions at the margin.

Crude Oil Production, 1985,
Assumptions[1] and with Medium Response[2]

Scenario III		
Total Production With Decontrol and Windfall Profit Tax	Percent Increase in Production With Decontrol and Windfall Profit Tax	Amount of Production Lost Due to the Tax as a Percent of Production with Decontrol and No Windfall Profit Tax[4]
3379	23.0	10.8
3487	26.9	12.0
3635	32.3	13.3
3871	40.9	15.0
4301	56.5	17.4

[3] Production under this scenario depends upon the controlled price, and therefore is not influenced by alternative assumptions with regard to the decontrolled price.

[4] Actual production losses under each price assumption are as follows: −2%, 411; 0%, 475; +2%, 557; +5%, 684; +10%, 908.

Enhanced Oil Recovery

The price control programs of the 1970's impeded several promising avenues for increased production, including enhanced oil (tertiary) recovery technology on old properties. Enhanced oil recovery refers to the introduction of steam or chemicals into reservoirs to force oil out. By raising well pressure, this tertiary approach helps to extract the oil that cannot be obtained through natural energy (primary methods) or water flooding (secondary methods). Decontrol has triggered a wave of new enhanced-recovery projects, but activity would be even greater without the tax.

About 460 billion barrels of crude oil have been discovered to date in the United States, according to the American Petroleum Institute. The industry already has extracted about four-fifths of the 148 billion barrels considered ultimately recoverable by conventional techniques. About 51 billion of the remaining 312 billion barrels might ultimately be recoverable with enhanced oil recovery technology (Lewin, p. 4).

California provides an example of the potential for increased use of tertiary methods. Heavy oil (API 16° gravity or less) accounts for about one-half of the 80 billion barrels discovered in California, and most of this must be extracted by enhanced recovery. To date, producers have recovered about 6 billion barrels, leaving about 34 billion barrels in place, mostly in Kern County. Many such projects are now in operation, primarily involving the use of steam injection. In 1979, California accounted for most of the 296,000 barrels/day recovered in the entire nation by steam-injection methods (Hallmark, p. 4).

The combination of price and environmental controls stymied investment in tertiary recovery during the decade of the 1970's. In that period, California state and local governments tightened their environmental standards, until they executed Federal standards in severity. These regulations added to the cost of enhanced-recovery projects by requiring the installation of expensive pollution-abatement equipment, and thus made a number of projects uneconomic. But with the end of price controls, environmental compliance proved to be less of an obstacle. That fact became obvious after August 1979, when heavy-oil prices became decontrolled, triggering a wave of new instruments in enhanced recovery.

California crude-oil production reached a peak of 1.0 million barrels/day in 1969 and then began to decline. Most properties had been producing for decades, and so production declined as reservoir pressure decreased. Production at many properties thus dropped below the base-production control level, and in the process became subject to the lower-tier price ceiling. In fact, many producers were forced to sell their heavy oil even below the ceiling price, because of the West Coast's limited refinery capacity for processing that type of crude into products demanded by the region's end-users. The refiners' problem also could be traced to price controls, which prevented the refinery modifications necessary to make increased use of heavy oil.

The windfall-profit tax treats oil produced through tertiary-recovery methods in a relatively favorable manner. Some production from old (pre-1980) fields would normally be taxed at the Tier 1 or 2 rate (70 or 60 percent). But where an enhanced-recovery project is started after 1979, the oil may be taxed instead as Tier 3 oil, at a 30-percent rate.

V. Summary and Conclusions

Federal price-control programs in effect throughout most of the 1970's held the average domestic producer price of crude oil below the world market level. By permitting refiners to pay less than the world price for domestic crude, Congress attempted to protect consumers from bearing the full impact of rising world prices. There is considerable debate as to whether that objective was achieved. Moreover, controls affected the supply side of the U.S. market, both by creating greater dependence on foreign oil and by leading to an inefficient allocation of resources. In this respect, the Energy Policy and Conservation Act — as well as earlier control programs — reduced domestic production substantially below the level that would have prevailed without controls.

Efficiency in satisfying any given level of national consumption requires that domestic producers expand crude-oil production to the point where the cost of the last barrel equals the cost of acquiring an additional barrel of foreign crude. Federal controls violated that condition, by holding the domestic selling price below the landed price of foreign oil, and thereby causing the industry to produce at less than the optimum production level. For every barrel not produced, the nation's dependence on foreign oil rose by an equivalent amount at a greater cost of resources.

The removal of price controls (January 28, 1981) has forced refiners to pay free-market prices for domestic crude oil. That means higher refined-product prices also, to the extent that refiners pass on those higher costs to consumers. But decontrol also should raise domestic production above the level that would prevail under continued controls. In fact, decontrol may bring about at least a temporary reversal in the production decline of the past decade.

But the windfall-profit tax will reduce that positive impact. For example, with supply elasticities of .2 and .3 for existing and new properties, respectively, and with a 2-percent

Appendix A
Windfall Profit Tax (WPT) Calculation, 1985[1]

	Tier I	Tier II	Tier III: Heavy Oil	Tier III: All Other Tier III Oil
Estimated Decontrolled Price[2]	53.93	53.93	42.38	53.93
Less Adjusted 1979 Base Price[3]	−19.92	−23.64	−28.23	−28.23
Windfall Profit Before Severance	34.01	30.29	14.15	25.70
Less Severance Tax[4]	− 1.84	− 1.64	− .76	− 1.39
Windfall Profit	32.17	28.65	13.39	24.31
Windfall Tax	−22.52	−17.19	− 4.02	− 7.29
Amount of Windfall Retained by Producers	9.65	11.46	9.37	17.02
Producer Realized Prices with Decontrol after WPT				
Adjusted Base Price	19.92	23.64	28.23	28.23
Amount of Windfall Retained by Producers	+ 9.65	+11.46	+ 9.37	+17.02
Producer Price with Decontrol after WPT	29.57	35.10	37.60	45.25

[1] All data in dollars per barrel.

[2] Price assumed to rise at the inflation rate plus 2 percent annually between 1980 and 1985.

[3] Base price adjusted upward over the 1980-85 period according to the method described in the law.

[4] Tax imposed by the states, assumed to average 5.4 percent of the windfall profit before severance.

Source: All computations by author.

real rate of price increase, decontrolled production would be 31 percent higher in 1985, and 30 percent higher in 1990, than the amounts that might be produced with continued controls. But the windfall-profit tax could reduce that production differential to about 18 percent in 1985 and 1990 respectively. And the more the decontrolled price of oil rises relative to prices of other goods and services, the greater will be the production losses attributable to the tax.

FOOTNOTES

1. The term "property" is used as defined in the Energy Policy and Conservation Act to mean a separate and distinct producing reservoir. (U.S. Department of Energy, **Monthly Energy Review,** January 1981, p. 99). A "reservoir" is a porous and permeable underground formation containing an individual and separate natural accumulation of producible oil or of oil and natural gas. In most situations, reservoirs are classified as oil or gas reservoirs by a regulatory agency. See American Petroleum Institute (1976, p. 7).

2. In this regard, crude-oil production differs from most manufacturing processes. With the latter, we assume that increasing capacity, (i.e., rate of attainable production), causes something like a proportionate increase in the amount of product that ultimately will be forthcoming. Crude-oil investments, however, must be described with reference to two dimensions: the rate of output to be achieved, and the total volume of crude available for ultimate production. For a discussion of this point, see Bradley (1967, p. 16).

3. American Petroleum Institute, American Gas Association, Canadian Petroleum Association (1980, p. 14).

4. See, for example, Duchesneau (1975) and Eppen (1975)

5. Herfindahl and Kneese (1974, p. 123).

6. This would be the average delivered price for imported oil at the refinery gate, including transportation costs. In actuality, average domestic producer prices probably would not **exactly** equal the average landed cost of imported oil because of quality differences. Crude oil is not a homogeneous commodity; viscosity, sulfur content and other characteristics vary and affect its value. Nevertheless, the price of imported oil would determine domestic prices in the manner described in the text.

7. The requirements for efficiency on the supply and demand sides of the U.S. crude-oil market, as well as the inefficiencies created by price controls, are discussed in detail by Arrow and Kalt (1979, pp. 9-27). Their work draws upon an earlier study by Roush (1976).

8. For a detailed discussion of these state programs, see McDonald (1971, pp. 29-55) and Bohi and Russell (1978, pp. 250-253).

9. For a description of the various Federal crude-oil price-control programs of the late 1970's, see MacAvoy (1977) and Montgomery (1977 and 1978).

10. In computing the average target price, the energy agency assigned stripper-well oil an upper-tier price rather than the price actually paid. That approach made it possible to increase the price of stripper-well oil without lowering the price of some other category of domestic oil. See Montgomery (1977, pp. 9 and 12) for a discussion of this point as well as the inflation adjustment.

11. Economists generally agree that controls held the average domestic producer selling price below the world market level. Economists also agree that the so-called entitlement program equalized the average cost of crude oil to each refiner regardless of the relative amounts of imported, lower-tier, or upper-tier imputs used — and that refiners paid a common average price for all oil that was below the world market level. See, for example, Cox and Wright (1978, p. 4) and Montgomery (1977, p. 37). There is widespread disagreement, however, about whether crude-oil price controls reduced refined-product prices below the level that would have prevailed without controls. Montgomery has argued that the entitlement program utilized competitive market forces to pass through the increased refiners' profits from price-controlled crude oil, from crude-oil producers to refined product consumers (1977, pp. 37-40). Phelps and Smith (1977) maintain that refined-product prices were not held down by the controls and entitlements, and profits were transferred from producers to refiners. They argue that world refined products are made from world crude. The U.S. imports refined products and therefore, U.S. refined product prices must reflect world crude prices. This is basically an empirical question, but with much conflicing evidence. See, for example, Deacon (1978).

12. The following analysis synthesizes an even more detailed analysis of the production effects of the Energy Policy and Conservation Act, made by Kalt (1980, pp. 107-111). For an earlier discussion, see Roush (1976, pp. 16-20).

13. There are also resources wasted on the demand side as a a result of controls. The entitlement program reduced the price of imported oil to a common average price for domestic and imported oil (P_r) which was below the world market price (P_w). In doing so, it raised the quantity of imported oil demanded above the quantity that would have been demanded had refiners been required to pay the world price for an incremental barrel of crude. The additional oil demanded had an incremental value to the economy of P_r. But to realize that value, the nation paid the world price, P_w, to foreign sellers of crude. The resources consequently wasted on the demand-side equalled the difference between the world price and the average refiner acquisition price for both foreign and domestic oil, times the additional quantity

demanded as a result of the entitlement program. We should note that the average refiner acquisition price for domestic and imported oil, P_r, under the entitlement program was between the world price, P_w, and the average controlled domestic price, P_c as shown in Chart 2. That price was not shown on the chart because it did not affect the domestic production of crude oil.

14. If marginal profit is increasing like compound interest, an owner of a reservoir will be indifferent at the margin between extracting and holding at every instant of time. Hotelling (1931) established the profit-maximizing condition for a firm managing a depletable resource. For a further discussion of the point see Solow (1974, pp. 1-6).

15. Kalt found that, on balance, controls tended "to encourage later rather than earlier extraction." See Kalt (1980, p. 132).

16. As indicated in footnote 11, some economists argued that refined-product prices already reflected world oil prices. They maintained that decontrolling domestic crude-oil prices would have no effect on refined-product prices.

17. This estimate was based on the assumption that the uncontrolled domestic-producer price rose at the inflation rate plus 2 percent — i.e., at a 2 percent real annual rate — over the 1980-90 period. Reported in "U.S. Windfall Tax Bonanza Based on $75 Oil Price in 1990" (1980, p. 3).

18. See assumption described in footnote 17.

19. The projected decline rate ("base level") is the average daily amount of oil removed from the property during the six-month period ended March 31, 1979, reduced by one percent per month (after 1978) for each month before the project-beginning date. See Price Waterhouse and Company (1980, p. 21).

20. There would be no "windfall" upon which to base the tax unless this condition prevailed.

21. Since controls were imposed on the selling price, average selling prices of lower- and upper-tier crude in the absence of controls would have risen to approximately the landed price for imported oil (before entitlements). The uncontrolled wellhead price would have roughly equalled the world price minus the average transportation costs incurred by domestic producers in supplying refiners. For reasons of data availability we used actual and estimated uncontrolled wellhead prices, rather than selling prices, in calculating possible production losses resulting from the Energy Policy and Conservation Act.

22. In its 1979 *Annual Report to Congress*, the U.S. Department of Energy forecast production for 1985 and 1990 under several categories that would correspond to existing properties, the most responsive being production from enhanced oil-recovery techniques. The imputed price elasticity for existing properties derivable from these forecasts is approximately .2.

23. That assumption was employed in most models of reserve additions. See Bohi and Russell (1978, p. 237) for a discussion of this point.

24. For example, Fisher (1964) estimated an elasticity for new-oil discoveries of .3 using data for 1946-55, but Erickson and Spann (1971) obtained an estimate of .8 using 1946-59 data. The U.S. Department of Energy, in its 1979 *Annual Report to Congress*, developed forecasts for 1985 and 1990 which imply an elasticity for new fields of around .3. For a survey of these and other models, see Kimmel (1977).

25. Estimates vary widely concerning the total amount of oil remaining to be discovered in the United States, both on and offshore. For example, one official source places the total undiscovered recoverable resource base at somewhere between 50 and 127 billion barrels; see U.S. Geological Survey (1975, p. 4). Another recent assessment places the estimate at between 14 and 32 billion barrels; see Nehring (1981, p. 175).

26. This is the same price assumption employed by the Joint Committee on Taxation in developing its 1979 estimates of the Federal revenues to be derived from the windfall-profit tax. The price assumption is used to analyze the production effects of decontrol, with and without the windfall-profit tax. Note that there would be no tax unless the uncontrolled domestic price remains above the adjusted base price.

27. Tier 3 encompases newly discovered oil, heavy oil and incremental tertiary oil. It receives preferential treatment in the law through a lower tax rate and an extra 2-percent annual increase in its base-adjusted price.

28. Their estimate, made in early 1979, underestimated the actual increase in uncontrolled prices that actually occurred by the latter part of that year.

29. For estimates of production under continued controls, see U.S. Congress, Congressional Budget Office (1979, p. 76).

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