A CRITICAL EVALUATION OF
PETROLEUM IMPORT TARIFFS:
ANALYTICAL AND HISTORICAL PERSPECTIVES

An Economic_ Policy Analysis

By

Keith B. Anderson and Michael R. Metzger

Bureau of Economics Staff Report

to the Federal Trade Commission

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EXECUTIVE SUMMARY

Recent years have seen calls for renewed government intervention in oil and gasoline markets. In particular, there have been a number of proposals for tariffs to restrict imports of oil and various petroleum products into the United States. This study examines the costs and benefits that would result if tariffs were used to restrict the imports of crude oil and gasoline into the U.S. We find that: (1) any such policy would undermine U.S. long-term "energy security" because it would result in increased consumption of U.S. oil reserves; (2) it would impose substantial costs on U.S. consumers and on the U.S. economy as a whole; and (3) it is likely to be a complicated and inefficient method of achieving any national objective. -

Any attempt to increase our energy security by limiting imports will actually reduce our long run energy security by speeding the depletion of domestic reserves. Tariffs or other restrictions that reduce the supply of imports raise oil prices in the U.S., thereby making domestic production more profitable. This would stimulate domestic production and speed the depletion of domestic reserves. Fewer domestic reserves work against, rather that for, the goal of energy security.

Such restrictions are not only counterproductive, but they impose significant costs on consumers and society in general. The study estimates that a tariff policy that raised the price of imported crude oil and gasoline by $5 per barrel would cost American consumers between $13.9 and $16.7 billion per year. The net cost to the economy as a whole would be between $3.6 and $3.8 billion per year.

The study's cost estimates are conservative, because a tariff or any other government policy intended to increase domestic production and exploration will necessarily be much more complicated than these estimates assume. For example, the study analyzes both oil and gasoline tariffs because placing a tariff only on imported oil would stimulate substantial imports of gasoline and other refined products. Therefore, a tariff on both oil and refined products would be needed to limit imports. However, history shows that any attempt to regulate petroleum markets is apt to be even more complicated than this and is likely to be filled with loopholes. For example, limitations on imports will create incentives for consumers of various petroleum products and producers who use different types of oil to try to shape the program to obtain maximum benefit for themselves. If policy making, as in the past, accedes to such pressures, the resulting inefficiencies would increase the costs of regulation beyond what we have estimated, and would limit the benefits obtained from any such program.

Assuming that government action is needed, the study concludes that a much more effective method of increasing our energy security would be for the government to purchase oil at current, relatively low prices, and increase the Strategic Petroleum Reserve. Subsidizing exploration may also be a viable policy instrument, but such a policy is likely to be quite complicated.

Import Restrictions and Energy Security

The decline in the price of crude oil, particularly during 1986, has resulted in claims that imports of crude oil must be restricted if we are to avoid becoming excessively dependent on foreign oil. Supporters of this argument contend that low prices are causing excessive consumption of oil and too little domestic production and exploration. To rectify these problems, policies, such as tariffs, have been advocated to raise crude oil prices in order to stimulate exploration and development. However, policies that increase domestic oil prices by limiting imports are unlikely to advance our energy security. They would reduce current consumption of imported oil, but would increase current consumption of domestic reserves and inevitably leave fewer domestic reserves to meet future needs.

The Costs of a Simple Tariff

In order to examine the economic effects of a tariff, we examine several possibilities. First, we consider a $5 per barrel tariff on both crude oil and gasoline. We then analyze separate $5 tariffs on gasoline and crude oil.[1] In addition to estimating the costs to the U.S. economy as a whole, we examine the effects on several segments of the economy: consumers of gasoline, producers of crude oil, producers who use crude oil to produce refined products, and the U.S. Treasury.

Our analysis indicates that a $5 tariff on both gasoline and crude oil would cause the U.S. economy as a whole to be worse off because losses suffered by gasoline consumers and refiners exceed the gains to crude producers and the tariff revenues generated. Such a tariff increases consumer payments for gasoline by between $13.9 and $16.7 billion per year. In addition, petroleum refiners suffer reduced profits of between $7.5 and $10 billion per year because the tariff increases the price of only one of the products refined from crude oil, while significantly increasing the costs of U.S. refiners. Imposition of this tariff leads to increased profits for domestic crude oil producers by between $12.4 and $13.4 billion per year.[2] The tariff revenues are between $6.7 and $8.2 billion per year. The sum of these effects amounts to a loss to the economy as a whole -- a deadweight loss -- of between $3.6 and $3.8 billion per year.

A tariff on gasoline alone imposes much smaller costs than a combined tariff on crude oil and gasoline. Consumer losses are approximately $300 million per year, and refiners gain almost the same amount. Thus, the net cost to the U.S. economy is

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[1] Results for tariffs of $10 per barrel are also reported in the Appendix.

[2] Of course, a large part of these gains would wind up going to owners of lease rights. The increased profitability of oil production would result in increased prices for leases.

relatively small.[3] This occurs because only a small increase in the price of gasoline is needed to increase domestic production sufficiently to eliminate the small quantity of current gasoline imports.

The estimated costs of a tariff on crude oil alone depend, to a greater extent than the other estimates, on the assumptions about the "world price" of oil and gasoline -- *i.e.*, the price paid to producers in other countries. If we assume that the world price does not depend on the quantity of imports demanded by the United States, then a tariff on crude oil does not impose direct costs on consumers, since refiners cannot increase the price of gasoline without losing all of their sales. On the other hand, if the price of imported gasoline rises when U.S. demand increases, then the gasoline price increase resulting from a crude oil tariff of $5 per barrel could cost U.S. consumers $8.9 billion per year.

Our estimate of the gain to crude oil producers also varies with the assumption about the effect of U.S. demand on the world oil price: if the import price is constant, we estimate crude producers would gain $7.7 billion per year, while their annual gains would be $11.9 billion if the import price increases. Under either set of assumptions, refiners' loses are approximately $12 billion per year. Finally, we estimate that no tariff revenues would be generated by a $5 tariff on crude oil alone as all imports would be eliminated and their place taken by imports of refined products and increased domestic production.

Under either assumption about the effect of U.S. demand on the world price of oil, the U.S. economy on net would suffer substantial losses from a crude oil tariff. If the price of imports is assumed not to change, the estimated net societal cost -- or

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[3] Even with alternative assumptions explored as part of a sensitivity analysis reported in the Appendix, the basic results remain the same. With different assumptions, a tariff on gasoline alone would cost consumers $5.9 billion per year, the gains to producers would amount to $5.8 billion and the cost to society would be approximately $100 million per year.

deadweight loss -- is $4.2 billion per year. If the import price changes, the annual net cost could come to $8.6 billion.

Complications in Design and Implementation

The losses described above are far from small. And yet, it is likely that the actual costs of any petroleum tariff would be greater than we estimate because any tariff is unlikely to be as simple as we assume. A firm can secure substantial financial benefits by obtaining special treatment under any regulatory scheme; and we expect that firms would seek such treatment.[4]

To obtain some insights into the special favors likely to be sought and their likely effect on the economy, we examined the history of petroleum regulation in the United States since the end of the second World War. During this period there have been two significant regulatory programs. First, imports were restricted under the Mandatory Oil Import Program (MOIP) between March 1959 and early 1973. Second, from 1971 until 1981 the industry was subject to domestic price controls. As part of this price control process, petroleum refiners were awarded the right to use price-controlled -- and therefore less expensive -- domestic crude oil under an Entitlements Program.

One of the major issues in designing a tariff program involves the choice of refinery inputs to be subject to the tariff. In our estimation we assume that crude oil is the only petroleum product used as an input into the refining process. However, refineries also can, and do, use partially refined products such as unfinished oils and motor gasoline blending stocks. If these products are not subject to a tariff, refiners will have strong incentives to avoid the tariff by importing these unprotected products. As a result, the effectiveness of the tariff in obtaining higher prices for crude oil producers may be reduced. An additional complication arises because the inputs used by petroleum refiners are also used by petrochemical producers. If

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[4] For example, if a firm that purchases imported crude oil can legally avoid paying the tariff through a loophole, its profits may be substantially increased.

these producers have to pay higher prices for their inputs, they will be less able to compete with foreign producers.

A second issue is whether imports from certain countries would be exempted from the tariff. Under the Mandatory Oil Import Program, imports from Canada and Mexico were, at least initially, not subject to import restrictions. Such exceptions benefit not only the countries obtaining special treatment, but also the firms able to purchase oil from these countries. There is likely to be pressure, perhaps attributed to foreign policy concerns, for similar exceptions from any new tariff program. To the extent such exceptions are granted, they increase the costs and may reduce the benefits of the tariff program.

Examination of the history of the MOIP and of the Entitlements Program suggests that any new program will eventually be used to achieve other objectives. Under both previous programs, substantial subsidies were awarded small refining firms. These subsidies have tended to maintain inefficiently small refining firms and thereby increase the costs of the U.S. petroleum refining industry. Maintaining inefficient refining capacity will make the U.S. less able to compete with foreign producers.

Similarly, special arrangements were made under both programs to encourage firms to make investments in Puerto Rico that would apparently have otherwise been unprofitable. In addition, the right to import additional oil under MOIP was used to induce the import and production of additional low sulfur oil. Finally, under both programs, petroleum firms in danger of going out of business have been able to petition for special help. All of these "special deals" contribute to the costs of the regulatory program by promoting or maintaining inefficient production in the petroleum or other affected industries.

If what is past is prologue, even larger costs than we have estimated are likely to accompany any new regulation of petroleum markets.

Will A Tariff Succeed in Meeting Its Objectives?

We also consider the effectiveness of a tariff in meeting the goals enunciated by supporters. We find that a tariff is likely to be an extremely costly way of achieving any of these objectives.

Supporters of a tariff often argue that a tariff is needed because the price of oil will rise precipitously at some point in the future. However, uncertainty over the future price of oil does not, in itself, provide a rationale for governmental intervention. The market will usually dictate the proper level of energy consumption. Consumers and producers adjust their behavior to reflect uncertainty over future energy prices. For example, consumers will not purchase large, fuel-inefficient cars if they expect the price of gasoline to be higher two years from now. Similarly, firms look at expected future prices as well as current prices in deciding whether to invest in equipment that makes extensive use of oil.

Finally, in making decisions about the proper level of exploration for new crude oil reserves, petroleum firms consider the price that they expect to receive at the time they actually produce any oil discovered. Where several years would pass between the beginning of exploration and the onset of production, producers will consider how prices are likely to change in the future in deciding whether to begin exploration. If prices are likely to rise, more exploration will be undertaken than would be economic at the current price.

Assuming that some government action is needed, we find that tariffs are a relatively costly and ineffective way to avoid excessive foreign dependence in the future. A tariff increases current crude oil production and may have only a limited effect on exploration and development.[5] Increasing current production does not promote future energy security because it reduces reserves available in the future. Subsidizing exploration is likely to be a superior policy, if any action is needed.

If policy action is needed to ensure that we have sufficient oil to withstand a temporary disruption in import supply, storing oil would be superior to a tariff. We can purchase oil today at relatively low prices and store it in case the disruption occurs. Storage would involve substantially smaller costs than a tariff because a tariff imposes much larger costs on consumers between now and some future date when a disruption may occur.

A tariff is also a very costly technique for raising governmental revenue. With a $5 per barrel tariff on both crude oil and gasoline, consumer payments for gasoline will increase by between $2.00 and $2.10 for each dollar of revenue raised. The net cost (deadweight loss) to the United States economy as a whole is between $0.45 and $0.55 for each dollar of revenue raised by the tariff.

Finally, a tariff cannot significantly improve the well-being of the refining industry. Imports make up only a small percentage of total gasoline consumption, and therefore a tariff cannot induce much substitution of domestic gasoline for imports.

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[5] Similar problems may exist with other policies -- such as increasing the depletion allowance -- which attempt to promote exploration by increasing the profitability of oil production. Even if a depletion allowance is limited to newly discovered oil, it would still stimulate domestic production and reduce total U.S. reserves.

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CHAPTER I

WHY IMPOSE A TARIFF ON PETROLEUM?

This study provides an analysis of the merit of recent proposals to impose import tariffs on crude oil and refined petroleum products. To accomplish this, we have identified the oft cited objectives of such tariffs and have analytically modeled the effects of a tariff to determine the likely gains and losses to various segments of the U.S. economy. We have, in addition, estimated the cost to the U.S. economy as a whole. We have further drawn on the history of attempts to regulate the petroleum industry to anticipate the probable administrative complexity of implementing such tariffs. Finally, we have used our results to examine the efficacy of such tariffs in accomplishing their stated goals.

The current chapter reviews the justifications for imposing import tariffs on petroleum and considers some of the economic background. The next chapter provides a summary of the analytic model we employ and the results of that analysis. In particular, we examine the effects on consumers, crude oil producers, producers of refined petroleum products, the U.S. government, and society as a whole. Chapter III draws upon experiences in implementing similar energy programs in the past to predict the pitfalls of adopting the current proposals. Chapter IV analyzes the efficacy of tariffs in accomplishing their cited objectives, drawing in part on the results presented in the prior chapters. A summary of our key findings is presented in Chapter V. Finally, a technical appendix is included that contains a detailed description of the analytical model discussed in Chapter II, as well as a complete presentation of the model's results.

Rationales for a Tariff

In recent years, petroleum tariffs have been promoted by various groups for three reasons: (1) to provide protection to domestic refiners, ostensibly to ensure that domestic refinery capacity would be sufficient to meet U.S. needs in the event of a disruption in the supply of refined product imports; (2) to ensure national energy security by maintaining the profitability of crude oil exploration and development; and (3) to provide additional government revenue to alleviate the growing federal budget crisis.

Crude oil is used to produce a variety of refined petroleum products that are used by the manufacturing, transportation, and residential sectors of the economy. U.S. petroleum product demand has exceeded domestic production of crude oil for many years. As a result, much of our demand has been met by importing either crude oil or refined products. The importation of refined products -- especially the more profitable light petroleum products such as gasoline and distillate fuel oil -- has become more important in recent years. While total imports of petroleum products have not increased since 1970, the mix has shifted considerably. The quantity of light products being imported increased approximately 127 percent between 1980 and 1985.[1] However, imports still constitute a relatively small share of total consumption in this country. In 1985, gasoline imports represented only about 5.6 percent of domestic consumption. For the first eleven months of 1986, imports constituted only 4.2 percent of consumption.[2]

During the first half of the 1980s, domestic operable refining capacity fell from 18.6 to 15.7 million barrels per day (bpd). During this period, the number of refineries in the United States fell by 106, approximately one-third of all refineries. The utilization rate of remaining refineries is well below historical levels.[3]

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[1] See U.S. General Accounting Office (1986), pp. 16-19.

[2] U.S. Department of Energy (1986b), p. 49

[3] See U.S. General Accounting Office (1986), p. 10. We note that many of the refineries that have closed since 1981 are small refineries that may have only been profitable because of the biases in favor of small refineries that existed under the Entitlements Program. (See pp. 26-28 below.)

Independent refiners have claimed that imports have been responsible for the closing of these refineries. They further claim that if product imports are allowed to continue to grow, they will jeopardize U.S. energy security interests. As a remedy, they have proposed tariffs on petroleum product imports to shelter domestic refiners from foreign competition. However, a recent report by the General Accounting Office concluded that recent refinery closings were better explained by economic, regulatory, and legislative factors than by heightened foreign competition. The report found little energy security justification for restrictions on product imports at this time.[4]

More recently, concern has been voiced over the effect of current low petroleum prices on the level of domestic crude oil exploration and development. It is argued that if these activities continue at their current depressed levels, insufficient crude oil will be readily available in the event of a supply disruption. Due to this energy security concern, tariff proposals have increasingly included imports of crude oil instead of, or as well as, refined products.[5]

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[4] The GAO report did, however, recommend that domestic refining capacity and needs be monitored in the future. (See U.S. General Accounting Office (1986), pp. 3-4.)

[5] A recent American Petroleum Institute (API) report argues that the recent decline in world petroleum prices poses a long term threat to U.S. energy security. API predicts that if crude oil prices remain at a $15 per barrel level indefinitely, then OPEC could regain control of the world market within three years as a result of increased energy consumption and closure of high-cost oil-producing wells outside of OPEC. This of course raises the specter of possible price escalations or embargoes whenever it serves OPEC's political or economic needs. It is of interest that in 1979 API correctly predicted that OPEC's market power would be reduced if the U.S. government decontrolled oil prices, although the process took only half as long as API then predicted. (See "The Delayed Cost of Cheaper Oil," *Forbes*, August 25, 1986, pp. 8-9.)

Finally, large current, as well as projected, Federal budget deficits have provided Congress with yet another incentive to seriously consider such tariff proposals. The recent dramatic decline in petroleum prices has been viewed by many as an opportunity to levy such a tariff as a new revenue source without causing any apparent increase in energy prices to end users.

Tariffs which have been discussed have varied not only in their magnitude but also in their scope. Refiners have generally promoted tariffs on petroleum products only and not on crude oil. These proposals often range between $2.00 and $2.50 per barrel.[6] Congress, on the other hand, has considered a much wider range of alternatives. In 1985, Representative Anthony of Arkansas proposed a 10.8 percent *ad valorem* levy on gasoline imports only.[7] In contrast, Senator Boren of Oklahoma proposed a $10 per barrel tariff on gasoline and a $5 per barrel tariff on crude oil imports.[8] Most other proposals have been for a $5 or $10 per barrel tariff on all imported products as well as crude oil, although one of the most recent called for a variable excise tax

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[6] See "Refiners' Problems Lie in U.S. Market," *New York Times*, June 23, 1985, p. 2F.

[7] See "Independent Refiners Will Soon Know Outlook for Import Curbs," *The Oil Daily*, September 16, 1985.

[8] See U.S. General Accounting Office (1986), p. 54.

that would be phased out as the price of crude oil went above $18 per barrel.[9]

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[9] The proposal made by Senator Dominici of New Mexico would levy a tax of $4 per barrel on crude oil and refined petroleum product imports, phasing down dollar-for-dollar as the price of crude oil exceeded $18. (See *Congressional Record--Senate*, August 15, 1986, pp. S11954-S11955.) We note that, if the price of oil is set by a profit maximizing cartel such as OPEC and if that profit maximizing price would lie between $18 and $22 in the absence of a tariff, Senator Dominici's proposal could greatly increase the likelihood of the world price rising. Increasing the price from $18 to between $20 and $22 would have no effect on the price of petroleum in the United States, so it would have no effect on U.S. demand for imported oil. While a price increase in such circumstances would reduce the quantity of oil demanded by foreign purchasers, the cartel could find it profitable to raise the price it charged because U.S. demand remains unchanged.

CHAPTER II

THE ESTIMATED COSTS OF A TARIFF

In this chapter, we summarize the analytical model used to investigate the benefits and costs of various tariff proposals and discuss the most important results of our analysis. The full model and a detailed presentation of the results are contained in the Appendix.

Description Of The Model and Its Assumptions

To investigate the impact of a petroleum import tariff on the U.S. economy, we employ a partial equilibrium, comparative static model of international trade.[10] Using standard supply and

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[10] We have modeled the world oil market as being approximately competitive, which we believe will best approximate the world oil market over the next five years. Developments in the last five years are consistent with this assumption: the abandonment of U.S. domestic price controls, a falling share of world production for OPEC in the face of production expansion in Mexico and Great Britain, stagnant or declining world petroleum demand, and the apparent decline in the ability of OPEC to negotiate and maintain production controls.

Another reason for our approach is that the informational needs of modelling OPEC as a (semi-effective) price-leading cartel are prohibitive. If foreign crude oil suppliers can wield significant market power in the future, then an effective decline in U.S. demand for their output could change the price which they choose to set. If these producers behave in a profit-maximizing manner, it is likely that they will respond by lowering their price. Alternatively, for political or punitive reasons, they might choose to sacrifice profits, at least in the short or medium run, by either maintaining prices or by raising prices.

A recent empirical study of the international petroleum market demand analysis, we first determine the changes in prices and quantities that would result from various alternative tariffs on imported crude oil and/or gasoline. From these prices and quantities, we calculate the tariff revenues, as well as the gains and losses to consumers and producers. Initially, it is assumed that a tariff will have no impact on world market-clearing prices. Subsequently, world markets are modeled explicitly and we recalculate the gains and losses to the various segments of the U.S. economy.

The analysis uses prices and quantities in 1985 in constructing the necessary demand and supply equations. However, given the dramatic decline in world petroleum prices, the 1985 figures are probably not a good starting point for the calculations, particularly since prices are unlikely to regain those relatively high levels in the near future. Accordingly, a hypothetical initial equilibrium is constructed that is more comparable to prices prevailing today and likely to prevail over the next five years. This initial equilibrium arbitrarily assumes a world market-clearing price for crude oil of $17 per barrel. From this price and from a comparable gasoline price of $22 per barrel, we estimate equilibrium quantities. These quantities represent the baseline for comparing each tariff's outcome.[11]

As indicated previously, tariff proposals have in the past been of varying scope and magnitude. For a variety of reasons, we have restricted our analysis to tariffs on crude oil and

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for the period 1971-1983 concluded that a market-sharing cartel model best explained the behavior of OPEC producers, although a competitive model best explained that of non-OPEC producers. (See Griffin (1985).)

[11] As part of a sensitivity analysis, we calculate the effects of the various tariffs for the case where petroleum prices returned to 1985 levels. As is described in the Appendix, the results are not significantly altered.

gasoline.[12] The six specific tariffs investigated in this study are: a $5 and a $10 per barrel tariff on crude oil imports; a $5 and a $10 per barrel tariff on gasoline imports; and a $5 and a $10 per barrel tariff on both imported crude oil and gasoline.

The benefits and costs of each tariff fall unevenly across the various segments of the U.S. economy. In this analysis, the following groups are distinguished: crude oil producers,[13]

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[12] First, some proposals have included only these two products. Second, we lack reliable estimates of the demand and supply elasticities for many refined petroleum products. Finally, there are a variety of reasons for believing that substantial tariffs are unlikely to be imposed on all refined products. First, the prices of some products could not be increased by a tariff because they are not imported into the United States. In 1985, the U.S. did not import aviation gasoline, petroleum coke, still gas, or certain oils used as petrochemical feedstocks. (See U.S. Department of Energy (1986a), volume 1, p. 24.)

For other products, *e.g.*, middle distillate and residual fuel oils, political constraints make the imposition of large tariffs unlikely. Users of these products have in the past had sufficient political power to at least partially avoid the higher prices that would result from import restrictions. Under the Mandatory Oil Import Program, extra imports of distillate fuel oil were frequently authorized by the Oil Import Appeals Board. (Dam (1971), pp. 19, 38-39) During the 1970s, imports of distillate fuel oil continued to receive more favorable treatment than imports of other products. (Kalt (1981), p. 17) Similar "special favors" involving residual fuel oil are found under both MOIP and the Entitlements Program.

Absent restrictions on imports of these two products and those products that are not imported by the United States, more than 35 percent of refinery output would be unprotected. (U.S. Department of Energy (1986a), vol. 1, p. 24) This does not differ much from merely protecting gasoline, since gasoline accounts for approximately one-half of refinery outputs.

[13] It should be noted that a significant portion of the benefits we attribute to crude oil producers would in fact accrue to owners of lease rights.

refiners (who are both consumers of crude oil and producers of gasoline), consumers of gasoline, and the U.S. government (who collects the proceeds of the tariff). The sum of the gains and losses of these four groups represents the net societal gain or loss. Since most tariffs result in net societal losses, this sum is traditionally termed the "deadweight" or "allocative inefficiency" loss.

Results: The Case of Constant World Prices

Initially we assume that any import tariff imposed by the U.S. will have no effect on prevailing world petroleum prices. This assumption is often referred to as "full pass-through". In this case, the post-tariff domestic price of crude oil will be identically equal to the $17_ per barrel world price plus the amount of the tariff on crude oil. Similarly, if a tariff is imposed on gasoline, the domestic price of gasoline will equal $22 per barrel plus the tariff amount. The single exception to this is when, as a result of a higher domestic price, the increase in domestic supply and the decrease in demand are sufficient to bring domestic supply and domestic demand into equality. At this so-called choke price, imports fall to zero, as do tariff revenues accruing to the government.

Table 2.1 presents the change in surplus and tariff revenues associated with three different tariff alternatives: a $5 tariff on crude oil imports, a $5 tariff on gasoline imports, and a $5 combined tariff on both crude oil and gasoline. Each alternative is discussed in turn.

A crude oil import tariff has the effect of raising the domestic price of crude oil. Accordingly, crude oil producers benefit while crude oil users, *i.e.*, refiners, suffer. Since refined oil products are traded in a world market (where price is assumed in this case to be unaffected by the tariff), the prices for these products are unchanged. Therefore, consumers are no worse off from the tariff, *i.e.*, the change in consumer surplus is zero. Domestic refiners must absorb the entire cost increase to continue to compete with imported gasoline. In the case of a $5 tariff, domestic crude price rises from $17 to $20 per barrel

Table 2.1

IMPACT OF IMPORT TARIFFS WITH FULL PASS-THROUGH: SURPLUS CHANGES AND TARIFF REVENUES
($billions/year)

	$5 Crude Tariff	$5 Gasoline Tariff	$5 Combined Tariff
Consumers:	0	-0.3	-13.9
Crude Oil Producers:	+7.7	0	+13.4
Refiners:	-11.9	+0.3	-10.0
Tariff Revenues:	0	0	+6.7
Net Societal Gain/Loss:	-4.2	-0.0	-3.8

NOTE: For the crude oil tariff, imports of crude oil fall to zero as the domestic price rises to $20.00 per barrel. For the gasoline tariff, imports of gasoline fall to zero as the domestic price rises to $22.10 per barrel.

whereupon domestic crude oil supply satisfies domestic demand.[14] Tariff revenues are zero, as imports are then zero. Net societal loss is $4.2 billion per year, which is the difference between the gain ($7.7 billion per year) to crude oil producers and the loss ($11.9 billion per year) to refiners.

A gasoline import tariff effectively raises the domestic price of gasoline. Accordingly, refiners benefit at the expense of consumers. Since the domestic price of crude oil is unchanged, crude oil producers are unaffected by the tariff. In the case of a $5 tariff on imported gasoline, the domestic price would rise only about a dime before domestic supply overtook domestic demand and imports fell to zero.[15] With zero tariff revenues and

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[14] Some reviewers have expressed surprise at the conclusion that the U.S. would become self-sufficient in crude oil if a tariff of $3 or more were imposed and have suggested that this could be the result of having assumed an excessively high elasticity of domestic crude oil supply. However, even if the supply elasticity was assumed to be 0.275 rather than the 0.55 assumed in our basic model, the results would not differ much. The price of crude oil would rise by $2.70 (instead of $2.95) before all imports are eliminated. Crude producer gains would come to $7.8 billion per year (instead of $7.7 billion) while refiner losses would be reduced to $11.2 billion from $11.9 billion. As a result, the total cost to society would be $3.4 billion per year rather than $4.2 billion. (See the sensitivity analysis on pp. 100-114 of the Appendix for details.)

[15] If the elasticity of supply of domestically produced gasoline (and therefore the elasticity of demand for crude oil by refiners) is less than we have assumed, the price of gasoline would rise somewhat more before all imports were eliminated. For example, the sensitivity analysis in the Appendix shows that if the elasticity of crude oil demand is only one-half of the value we assumed, the price of gasoline would rise by about $2. With this elasticity, domestic production must increase by 600,000 barrels per day before all imports are eliminated. While refiners would gain approximately $5.8 billion under this assumption, the tariff would cost consumers $5.9 billion. The aggregate cost would come to approximately $100 million per year. (See

no change in crude oil producer surplus, the net societal loss is simply the difference in the gain to refiners, $300 million per year, and the loss to consumers, a figure only slightly larger. The net societal loss is minimal for this tariff alternative. There is zero tariff revenue, and little apparent gain for refiners because foreign gasoline supply is less than five percent of domestic demand in our baseline.

A combined tariff on both crude oil and gasoline imports essentially combines the effects of the two single tariffs. Both domestic crude oil and gasoline prices increase, making crude oil producers unequivocally better off and consumers worse off. Domestic refiners benefit from the higher price of gasoline, but suffer from a higher price for crude oil. As is seen in Table 2.1, the net effect for refiners is negative. While tariff revenues are significant -- $6.7 billion dollars per year -- it is at a cost of $13.9 billion per year to consumers and $3.8 billion per year for society as a whole.[16]

Results: The Case of Changing World Prices

Even if the world market for petroleum is competitive as we have assumed, the imposition of an import tariff on petroleum may effect world prices. This would occur if (1) an increase (decrease) in the world price induces limited increases (decreases) in the supply of crude oil and/or gasoline produced outside of the United States and (2) the United States accounts for a large enough portion of total petroleum consumption that changes in U.S. demand for imports can cause changes in the world price. The assumption that world price depends on the U.S. demand for imports is typically termed "partial pass-through".

Appendix, pp. 100-114, for details.)

[16] It is interesting to note that upon doubling the tariff amount to $10, the losses to consumers and to society essentially double as well, while the gain in tariff revenues is a mere 25 percent.

The results of the full pass-through and partial pass-through assumptions are very comparable, as is seen in Tables 2.1 and 2.2. This arises for a different reason with each tariff alternative. First, when we assume a partial pass-through, the simple tariff on crude oil only causes the world price of crude oil (as opposed to the price in the U.S.) to decline slightly. However, the higher domestic crude oil price increases U.S. refinery costs, reducing the domestic supply of gasoline. The resulting increase in U.S. demand for gasoline imports significantly bids up the world price of gasoline. In terms of net benefit to the United States, the slight decline in the world price of crude oil is outweighed by the increase in the world price of gasoline. Second, imposing a tariff on gasoline that eliminates imports will have very little effect on the world price of gasoline because of the relatively small amount of gasoline imported by the U.S. Third, a combined tariff decreases the world price of crude oil, but increases the world price of gasoline relatively more. The resulting pass-through of the tariff to the final prices is approximately 90 percent for crude oil and 120 percent for gasoline, which together yield an outcome similar to the full pass-through case.

For the simple tariff on gasoline and the combined tariff on both commodities, the net societal loss is nearly identical whether one assumes full or partial pass-through. This is not true for a tariff on crude oil alone. With partial pass-through, a $5 tariff on crude oil imports involves roughly the same loss to refiners as with full pass-through, while crude oil producers pick up an additional $4 billion per year and consumers go from no loss to about $9 billion. The net societal loss from a crude tariff under a partial pass-through assumption is more than double the net loss associated with full pass-through.

The greater losses associated with a partial pass-through model run counter to the traditional wisdom that changes in world crude oil prices resulting from a U.S. tariff make the tariff more attractive. The key reason for our result is that more gasoline is imported when a crude oil tariff increases the cost of refining in the U.S.

Table 2.2

IMPACT OF IMPORT TARIFFS WITH PARTIAL PASS-THROUGH: SURPLUS CHANGES AND TARIFF REVENUES
($billions/year)

	$5 Crude Tariff	$5 Gasoline Tariff	$5 Combined Tariff
Consumers:	-8.9	-0.3	-16.7
Crude Oil Producers:	+11.9	-0.0	+12.4
Refiners:	-11.6	+0.3	-7.5
Tariff Revenues:	0	0	+8.2
Net Societal Gain/Loss:	-8.6	-0.0	-3.6

NOTE: For the crude oil tariff, imports of crude oil fall to zero as the domestic price of crude oil rises to $4.60 above the world price of $16.90 per barrel. For the gasoline tariff, imports of gasoline fall to zero as the domestic price of gasoline rises $.20 above the world price of $21.90 per barrel.

CHAPTER III

COMPLICATIONS IN THE DESIGN AND IMPLEMENTATION OF A TARIFF

In this chapter, we consider some of the institutional, political, and administrative issues that would arise in attempting to implement a tariff in this industry. While we focus here on the problems that would arise with a tariff, similar problems are likely to arise with any program of government regulation that attempts to alter oil exploration, production, refining, or trade.

The analysis in Chapter II provides estimates of the costs that would result from the imposition of a tariff on crude oil and/or on gasoline. However, those estimates are based on the assumption that the tariff is simple to administer and that there are no exceptions for certain domestic users or for imports from certain countries. While it is necessary to make such assumptions in order to make the estimation process tractable, both the history of previous governmental efforts to regulate the petroleum industry and the benefits that could be reaped by obtaining a special exemption suggest that any tariff will be considerably more complex than we have assumed.[17] This added

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[17] The complexity involved is recognized by leaders in the oil industry. According to George Keller, chairman of Chevron Corporation and chairman of the American Petroleum Institute, "The kind of solution [to the industry's problems that is needed] is not going to be the kind of simple one that can be suggested by the industry. We've got a problem here that is a lot more complex than a lot of us, and a lot in my industry imply." ("Concern Grows Over Rise in U.S. Oil Imports," *Washington Post*, March 8, 1987, p. H-3)

complexity is likely to create even more inefficiencies and net cost than we estimate with our simple model.[18]

To understand the potential complexity and inefficiencies of a tariff, we draw heavily on the history of petroleum market regulation in the period since World War II. Crude oil and petroleum product markets have been regulated during most of this period. Beginning in 1955, the U.S. government sought voluntary limitations on crude oil imports. After two voluntary programs failed to limit imports sufficiently, the Mandatory Oil Import Program was imposed in March 1959.[19] This program remained in effect until early 1973.[20] Beginning in August 1971, petroleum products were subjected to domestic price controls.[21] In one form or another, these controls remained in effect until January 1981.[22] If what is past is prologue[23], an examination of the experience with these programs should provide insights into the administrative complexities of any future attempts to impose economic regulation on the petroleum industry.

What Refinery Inputs Would Be Subject to a Tariff?

In 1985, almost nine percent of refinery inputs consisted of natural gas liquids, unfinished oils, and motor gasoline blending

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[18] The Department of Energy has also noted the likelihood of requests for exemptions and the costs that could result if such requests are granted. (See U.S. Department of Energy (1987a), p. 73.)

[19] For a history of the oil import programs, *see* Dam (1971).

[20] Kalt (1980), p. 7.

[21] Kalt (1980), p. 26. In addition, there have been several small tariffs which have been imposed on imported oil. However, these restrictions have had little effect; and we ignore them here. (See Kalt and Stillman (1980), p. 7.)

[22] Harvey and Roush (1981), p. vii.

[23] Apologies to William Shakespeare.

stocks.[24] If these products are not included in any tariff, refiners will have strong incentives to evade the tariff by importing intermediate products that were not profitable to import when there was no tariff. For example, if unfinished oils were not subject to a tariff, refiners could find it profitable to do some preliminary refining abroad and then import unfinished oils and residual fuel oil rather than crude oil. Similarly, if a tariff were imposed on finished gasoline, but not on motor gasoline blending stocks, strong incentives would be created for the importation of blending stocks which would then be converted to finished gasoline in this country.

While it may appear that the solution to this problem is simply to impose the same tariff on intermediate products as on crude oil, two considerations seriously complicate this issue. First, imposition of the same tariff on intermediate products and crude oil may not eliminate the incentive to import unfinished oils rather than crude oil. By increasing the use of semi-refined products as refinery inputs, the percentage of gasoline and other light products in refinery output can be increased. And, if as seems likely, heavier products such as middle distillate and residual fuel oil do not receive tariff protection, there will be strong incentives to increase the output of the lighter products.[25]

Second, some of these intermediate products are also used as inputs by the petrochemical industry, which is dependent on

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[24] See U.S. Department of Energy (1986a), vol. 1, pp. 24 and 28. In making this calculation, inputs used in PAD III were excluded since the figures for this district include inputs used by petrochemical facilities as well as those used by petroleum refineries.

[25] Indeed it is instructive to note that under the MOIP, refiners were not free to substitute imports of unfinished oils for imports of crude oil at will. Additional limits were placed on imports of unfinished oils: a refiner was permitted to use only 10 percent of his crude oil quota allocation to import unfinished oils. (Dam (1971), p. 15)

exports for much of its sales.[26] Imposing tariffs on these intermediate products, as well as imposing tariffs on refined products that are also used as petrochemical feedstocks, would substantially reduce the profitability and competitiveness of the U.S. petrochemical industry. As a result, opposition to such tariffs can be anticipated. Further, the history of the MOIP suggests that the petrochemical industry is likely to succeed in obtaining some kind of special solution to its problem.[27] Under

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[26] U.S. International Trade Commission (1985).

[27] One possible way to maintain the international competitiveness of the petrochemical industry would be to refund the cost of the tariffs on products exported from the U.S.. (See Dam (1971), p. 49) However, such a scheme in itself would involve a substantial amount of administrative complexity. If the government were to pay a firm an amount equal to its increased costs of producing petrochemicals that are ultimately exported, such a payment would be considered an export subsidy. As a result, other countries could countervail against the payment. In order to avoid being subject to countervailing duties on the exported petrochemicals, the program would have to provide a refund of tariffs charged on imported oil. Alternatively, the government could simply refrain from collecting the tariff on crude oil to be used in the production of petrochemicals for export.

While a program that rebated or excused the payment of tariffs on crude oil used to produce petrochemicals for export could conceivably maintain the profitability of firms that actually use imported crude oil, it would not help firms that use domestic crude. Since a tariff would result in an increase in the price of domestic crude along with that of imported oil, petrochemical firms that utilize domestic crude oil would remain at a competitive disadvantage in world markets because they would have no tariff payments to excuse. To avoid doing this, it might be necessary to provide petrochemical firms with rights to import crude duty free and then allow these rights to be sold.

In addition to these complexities, there would be the additional problem of determining the correct level of refund. Given the variety of inputs and the variety of products produced by the petrochemical industry and the possibilities for

MOIP, the petrochemical industry was allocated crude oil quotas beginning in 1966.[28]

To the extent refiners are able to avoid the costs of the tariff by importing unrestricted products, a tariff on crude oil will expand the demand for domestic crude oil less than we have estimated. As a result, the gains to domestic crude producers may be considerably smaller than we have estimated. Further, if the tariff causes refineries to alter the mix of products they import, the increase in the cost of gasoline production will be greater than we have estimated.

Would Imports From All Countries Be Subject To A Tariff?

Attempts to exempt imports from certain countries would also be likely. Such requests may be couched as foreign policy concerns.[29] For example, concerns over the ability of countries such as Mexico to repay their foreign debt could create pressure to exempt oil from these countries and thereby to provide additional revenues to these countries. In addition, domestic firms who import products from these countries would seek to have their imports exempted. How much would such exemptions raise the cost of the import restrictions to the U.S. economy?

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substitution among inputs and outputs, this would be an extremely difficult task.

[28] Dam (1971), p. 49.

[29] Canada is already protesting a small tariff Congress imposed on petroleum products in 1986 to help pay for the toxic waste cleanup program. ("Trading Partners Hit U.S. Import Surcharges," *Washington Post*, October 29, 1986, p. G-2.) While taxes were imposed on both domestic and imported petroleum products, the tax on imports -- 11.7 cents per barrel -- is higher than that on domestically produced products -- 8.2 cents per barrel.

Would these exemptions create such large loopholes that many of the benefits of the program would be eliminated?[30]

Again, an examination of the history of the Mandatory Oil Import Program and of the Entitlements Program of the 1970s is instructive. Kalt reports that during the Entitlements Program special treatment was provided to refineries located in the Virgin Islands, Puerto Rico, the Hawaiian Foreign Trade Zone, the Panama Canal Zone, and Guam.[31] While Kalt provides no

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[30] In order to meet the concerns of special interest groups such as consumers of middle distillates and residual fuel oil and producers of petrochemicals, it is necessary to grant special treatment to the marginal barrel of imports. Only by altering the restrictions on the marginal imports can the price of the product be affected. In contrast, it is possible to grant some of the rents resulting from the tariff program to foreign countries by allowing them to export a fixed quantity of crude oil or refined products to the United States duty free. If the quantity that can be imported duty free is limited, such exceptions will have no effect on the prices of crude oil or petroleum products and therefore would not undermine the protection afforded to the domestic industry. However, such grants to foreign countries would increase the costs to the U.S. economy since the tariff revenues would be lower than what we have estimated. For example if, as part of a $5 tariff on crude oil and gasoline, Canada and Mexico were permitted to export to the U.S. duty free the approximately 1,200 barrels of crude oil per day that they exported in 1985, foregone tariffs would amount to more than $2 billion per year. This would decrease tariff revenues by at least 25 percent and increase the societal cost of the tariff by more than 50 percent.

[31] Kalt (1981), p. 121 and n. 24. Refineries located in these areas received entitlements for sales to the United States. Refineries located in the Bahamas were also eligible for entitlements during most of 1975. Special arrangements were also made under the Mandatory Oil Import Program for refineries located in Puerto Rico owned by Caribbean Refining Company, a subsidiary of Gulf, and Commonwealth Oil and Refining Company. (Shaffer (1968), pp. 76-81)

explanation for this special treatment, refiners received substantial benefits from entitlements. Thus, it is possible that these refiners lobbied for such special treatment.[32]

a. Imports from Canada

Extensive exceptions for imports from neighboring countries were granted under the MOIP. The most important quantitatively was the exception for Canadian oil. The official justification for the MOIP was concern about the security of our energy supplies, and policy makers found it difficult to argue that there was a security problem with Canadian oil imported via overland routes.[33] However, special treatment for Canadian crude was probably also sought by Northern Tier refiners who made

[32] Dam argues that some of these special deals were necessary because refineries highly dependent on certain imported crude oils would be competitively disadvantaged if not provided such special deals. (Dam (1971), pp. 29, 44) This argument appears, however, to be incorrect. The imposition of a crude oil quota would be expected to lead to approximately equal increases in the price of domestic and imported crude oil. Thus, a refinery operating on imported crude should not find that its costs had increased more than a refinery running domestic crude. Further, quota rights were allocated on the basis of total refinery inputs and thus the rents associated with quota rights went equally to those who imported and those who did not.

[33] Dam (1971), p. 29. Note, however, that this argument is incorrect if a supply interruption elsewhere in the world would cause Canadian oil to be diverted to other consumers unless the U.S. matched an increase in the world price. For example, as discussed in note 36, below, there was concern that Canadian oil was being imported into this country while less-expensive imported oil was being consumed in Canada. In the event of a disruption of oil from other parts of the world, it is likely that the Canadian oil would have been consumed at home. Thus, U.S. supply would have been upset in the same way as if we had directly imported oil from the source whose supply was cut off.

extensive use of Canadian crude and therefore stood to gain substantially if this oil could be imported without restriction.[34]

As would be expected, because there were no restrictions, imports of Canadian oil grew substantially. Canadian imports into Petroleum Administration for Defense districts (PADs) I through IV -- all of the U.S. with the exception of the West Coast, Arizona, and Nevada -- were 60,500 barrels per day in 1960, 8.2 percent of all imports into these areas. By 1969, they had increased to 341,200 barrels per day. This was 33.8 percent of total imports. West Coast imports of Canadian oil grew from 46,000 barrels per day -- 15.6 percent of total imports -- in 1960 to 206,800 barrels per day -- 52.5 percent of the total -- in 1969.[35]

This continuing growth in Canadian imports gave rise to various efforts to limit the flow. First, at least partially in response to fears in the United States that non-Canadian crude oil was indirectly reaching the U.S. through Canada, the Canadians imposed limits on the use of imported crude in their country.[36] Second, a secret agreement was negotiated between the U.S. and Canada in 1967 imposing "voluntary" limits on the export of Canadian oil to the U.S.[37] Because this agreement did

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[34] Dam reports that it was believed that special treatment for Canadian oil was necessary to avoid placing the Northern Tier refiners at a competitive disadvantage. (Dam (1971), p. 29) While this argument appears to be incorrect (see note 32, above), it does suggest that these refiners saw substantial benefit from obtaining special treatment for imports of Canadian oil.

[35] Dam (1971), p. 30.

[36] Dam (1971), p. 31. Imported oil was thought to be reaching the U.S. because of increased consumption of imported oil in Canada which freed their domestic oil for export to the U.S. The restriction was that gasoline made from imported oil could not be sold west of a certain "energy line" which ran in a north-south direction along the Ottawa Valley.

[37] See Dam (1971), pp. 30-31.

not provide any enforcement mechanism, it failed to stem the growing tide of imports.

Finally, on March 10, 1970, mandatory limitations were imposed on imports of Canadian oil. However, these restrictions still were specially tailored to protect the interests of Northern Tier refiners and crude producers located in the upper Midwest.[38]

b. Imports from Mexico

Imports from Mexico were also exempt from the Mandatory Oil Import Program restrictions if the oil entered the United States overland. In the 1960s, imports of Mexican oil were much smaller than those from Canada, and these imports did not threaten to undo the protection-scheme to the same degree as Canadian imports.[39] However, the experience with imports of Mexican oil provides an interesting case study in the extraordinary inefficiencies that become profitable in an attempt to gain some of the rents resulting from restrictions on imports.

In part, Mexican oil did not flood into the U.S. because there were no crude oil pipelines crossing the border. Mexican oil was carried to refineries on the East Coast by ocean tanker. If the oil came into the country by ship, however, it was not eligible for the "overland" exemption. In order to avoid this problem, a highly expensive scheme known variously as the "Brownsville Loop," the "Brownsville U-Turn," and "El Loophole" developed. As described by Kenneth Dam, rather than being shipped directly to the East Coast refineries,

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[38] Dam (1971), pp. 32-34.

[39] In 1967, Mexico produced only about 364,000 barrels per day accounting for about one percent of world production. (*Statistical Abstract of the United States, 1969*, p. 847.) In 1985, Mexico produced at a rate of 2,797,000 barrels per day, accounting for 5.2 percent of world production. (*Oil and Gas Journal*, December 30, 1985, p. 67.)

"Mexican oil was shipped by ocean tanker to Brownsville, Texas (where it was treated as being landed in bond [*i.e.*, to be re-exported]), loaded on a truck, hauled across the border into Mexico and immediately brought over the border again into the United States, reloaded on tankers, and shipped to the East Coast. The second entry qualified for the overland exemption, whereas the first entry being under bond, was treated as not counting under the Mandatory Program."[40]

Use of the Import Restriction Program for Other Purposes

Both the MOIP and the Entitlements Program were used to advance policies not directly related to the original purposes of these programs. If similar uses were to be made of any new import restriction program, inefficiencies would be introduced into other markets and the inefficiencies in petroleum markets would be increased beyond what has been already suggested.

a. Efforts to Benefit Small Refiners

Under both the MOIP and the Entitlements Program, regulations were structured to provide extra benefits to small refiners. Under the MOIP, quota rights were allocated on a sliding scale which provided small refiners with proportionately more of these valuable rights.[41] A bias in favor of small

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[40] Dam (1971), pp. 35-36.

[41] Initially refiners received import rights equal to 12 percent of their daily refinery inputs on the first 10,000 barrels per day of refinery input. On any daily input in excess of 300,000 barrels, import rights equal to only 4 percent of input were awarded. (Dam (1971), p. 20.) This advantage was maintained and even expanded over time so that by 1972, in PAD districts I through IV, import quota was granted equal to 21.7 percent of the first 10,000 barrels per day of refinery input. On input in excess of 100,000 barrels per day, the allocation was only 3.8 percent. The relative advantage provided to small

refiners was continued in the Entitlements Program. Extra entitlements were awarded to refineries processing less than 175,000 barrels per day.[42] In addition to the Small Refiner Bias, Congress and the administrators of the Entitlements Program provided other benefits to small refiners.[43] It has been estimated that benefits provided to small refiners between November 1974 and July 1977 were worth $1.872 billion. In July 1977, benefits were being provided at a rate of approximately $1.125 billion per year.[44] These benefits were most likely achieved at an increased cost to consumers and other refiners that more than outweighed the benefits received.

It is likely that in many cases the firms favored by the small firm bias in the petroleum regulations were too small to be efficient. Scherer, *et. al*, have estimated that in 1965 a petroleum refinery needed to have a capacity of at least 200,000 barrels per day (bpd) in order to achieve all production efficiencies. A refinery with only one-third that capacity was estimated to have costs that were 4.8 percent above this minimum cost.[45] Even greater diseconomies from building a refinery of less than 200,000 bpd are reported by the Department of

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refiners was even greater on the West Coast -- PAD V-- where in 1972 import quota equal to 67.2 percent of refinery inputs was granted for the first 10,000 barrels per day of input. For input in excess of 100,000 barrels per day, the marginal quota rate was only 5.6 percent. (U.S. Department of Energy (1978), p. 28.)

[42] U.S. Department of Energy (1978), p. 28-30.

[43] U.S. Department of Energy (1978), pp. 22-23.

[44] U.S. Department of Energy (1978), pp. 25, 31.

[45] Scherer, *et.al*, (1975), p. 80. Since these figures only consider production economies and do not include the increased costs of transporting higher levels of output over greater distances, somewhat smaller refineries may be efficient, particularly in more sparsely populated areas.

Energy.[46] Finally, small refineries account for less and less of the total industry, confirming that smaller refineries are not competitive.[47]

The special treatment accorded small refiners under both the MOIP and the Entitlements Program arose from a combination of factors. The first is apparently effective lobbying by small refiners who stood to gain substantially from this special treatment. Special treatment was needed for these refineries to survive. In addition, legislators may have been easily convinced to provide such assistance in the philosophical belief that small is better than large. Thus, it would not be surprising for any new import restrictions to quickly come to provide benefits to small refiners, and additional costs to consumers.[48]

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[46] For refineries in the 90,000 to 120,000 bpd range, fixed investment costs per barrel of capacity are reported to be ten percent in excess of the cost or a 200,000 bpd refinery. Operating costs per barrel are increased ten percent if a refinery has a capacity of approximately 80,000 barrels. (U.S. Department of Energy (1978), p. 66)

[47] In 1980, refineries with a capacity of 30,000 bpd or less accounted for 58 percent of all U.S. refineries. In 1982 and 1984, the percentages were 54 and 48 percent. By 1986, refineries in this size class accounted for only 44 percent of all refineries in this country. (See U.S. Department of Energy (1986a) vol. 1, p. 63.)

[48] For example, a program could be structured so that a refiner could import a certain quantity of oil without payment of the tariff and this quantity could be structured in a way to provide greater benefits to small refineries. On the other hand, the influence of small refiners may have declined since the end of the Entitlements Program in 1981. The number of refineries with a capacity of 10,000 barrels per day or less declined from 102 in January 1980 to 49 in January 1986. The number of refineries with capacities between 10,001 and 50,000 barrels per day fell from 122 to 80, while the number with capacities in excess of 100,000 barrels per day only declined from 51 to 47. (U.S. Department of Energy (1986a), vol. 1, p. 63)

b. Discretionary Use of the Import Program

Another feature of both the Mandatory Oil Import Program and the Entitlements Program was the ability to obtain special relief if a refiner could convince the administering authority that it was in dire straights or was particularly deserving. Such a program may be almost inevitable in any substantial tariff program as no one wants to be responsible for the closing of existing firms or plants.

While such a special relief program may begin small, there are strong incentives for it to grow rapidly.[49] During the first twelve months of the Entitlements program, only about $85 million of relief was provided by Exceptions and Appeals Relief. By the late 1970s, the Exceptions and Relief process was annually distributing rights worth several hundred million dollars.[50]

In addition to providing relief to supposedly failing firms, the discretionary authority has been used, particularly under the MOIP, to further other societal goals such as reducing air pollution and furthering economic development. Again, this is not surprising given the economic value of exceptions and the ability of administrators and legislators to further other goals by appropriately awarding some of these benefits. In the late 1960s and early 1970s, special import quota was allocated to firms that

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[49] As Kalt observes in discussing the discretionary portion of the Entitlements Program (the Exceptions and Relief program): "Competition and the expenditure of resources (that is, lobbying) for the discretionary nature of the Exceptions and Appeals process is not subject to free rider problems. A successful applicant for Exceptions and Appeals grants is the sole beneficiary, whereas an individual refiner promoting, say, an expansion of the Small Refiner Bias must share any increase in the bias with an entire class of refiners." (Kalt (1971), p. 63)

[50] Kalt (1981), p. 63.

either imported low sulfur residual fuel oil or installed refining capacity to produce that product in this country.[51]

Both the MOIP and the Entitlements Program have been used to further economic development, particularly in Puerto Rico. First, under the MOIP crude oil supplies for refineries located in Puerto Rico were not subjected to the same controls as imports to mainland refineries. According to Edward Shaffer, this was done out of concern for economic development in Puerto Rico.[52]

Additional "special deals" were made during the MOIP granting producers willing to construct petrochemical facilities in Puerto Rico extra import rights and allowing them to import gasoline into the United States. In 1965, Phillips Petroleum was granted quota rights estimated to be worth more than $15 million per year in return for building a petrochemical plant in Puerto Rico.[53] Since Phillips insisted on both of these approvals as conditions for constructing the plant, it was apparently only feasible with these kinds of subsidies. Similar "special deals" were later concluded with Union Carbide, Sun Oil, and Texaco.[54] Under the Entitlements program, special treatment for petrochemical facilities in Puerto Rico continued.[55]

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[51] Dam (1971), pp. 40-43.

[52] Shaffer (1968), p. 77.

[53] Dam (1971), p. 45. Phillips was granted a crude and unfinished oils quota of 50,000 barrels per day and was permitted to ship 24,800 barrels of gasoline per day to the mainland U.S. (Shaffer (1968), p. 81)

[54] Shaffer (1968), pp. 82-83, Dam (1971), p. 45. As part of its agreement, Union Carbide agreed to purchase a portion of its petrochemical feedstocks from Commonwealth Oil and Refining Company, a competing producer of petrochemicals. This was the first time that the government had directed the supplier from whom a firm was to purchase. It is not clear how the price of these transactions was to be determined. (Shaffer (1968), p. 83.)

[55] Kalt (1981), p. 62.

Use of the benefits of an oil import tariff to promote other social goals would again increase the costs of the tariff beyond what is estimated in Chapter II. While awarding additional rents to firms that are successful in the political process may not limit the effectiveness of the quota, it will promote inefficient production either in the oil industry or in oil-using industries who receive the benefits. If the tariff favors inefficient refiners, the costs of producing gasoline will be greater than they need to be. If the benefits go to producers of petrochemicals who are relatively inefficient and only profitable because of their favored status, the total cost of petrochemical production is increased. Since these costs are not included in our earlier calculations, those estimates understate the actual costs involved.

In addition, resources will be expended in seeking these special benefits. If petroleum imports were not restricted, resources would not be used in this "rent seeking" activity and the resources could be used to produce other goods and services valued by society. Thus, to the extent that the presence of an import restriction program gives rise to this rent seeking to obtain special deals, it imposes real costs on society. These costs should also be considered in evaluating the desirability of the restrictions. Finally, the government will incur administrative costs in deciding who should and who should not receive these benefits.

Conclusion

In sum, substantial economic benefits would accrue to parties who obtained exemptions from a tariff that allow them to import without restrictions. Such special deals could take the form of exemptions for certain products, for products imported from certain countries, or just for imports by certain firms. Because these rights are valuable, we expect that they would be strenuously sought through the political process. However, as such exemptions are granted to one group, they inevitably create other distortions that require additional grants of special relief. As a result, an effective policy restricting petroleum imports becomes increasingly hard to maintain. Further, producers that receive special treatment under the regulations will operate inefficiently. In addition, the cost of the resources expended in seeking these special exemptions and the growth in the administrative costs of such a program will further increase the costs of any tariff program.

Based on the experience of past attempts to regulate the petroleum industry, it is likely that any tariff or other economic regulatory program will be much more complex than is assumed in Chapter II. If some imports of crude oil or gasoline are exempted from the tariff, the benefits of the tariff program are likely to be lower than we have estimated. Further, the various special deals are almost certain to increase the costs of the program, suggesting that we have understated the social costs of a tariff.

CHAPTER IV

AN ANALYSIS OF THE JUSTIFICATIONS FOR A TARIFF

As discussed in Chapter I, some supporters of governmental action to aid producers of crude oil and/or gasoline argue that a tariff is needed to enhance the security of U.S. crude oil supply. Others argue that action is needed to insure an adequate refining industry in this country. Still others suggest that a tariff would be an efficient way to raise revenue to reduce the federal deficit.

In this chapter, we explore the validity of these claims in light of our estimates of the effects of a tariff. We find that a tariff does not appear to be an efficient way to deal with concerns about the future availability of crude oil. In addition, we find little reason for concern about the health of the U.S. refining industry, although certain refiners in the U.S. could benefit from a tariff. Finally, we discuss the costs of using a tariff as a revenue raising mechanism.

Concerns Over Future Crude Oil Supplies

Advocates of imposing tariffs on imports of crude oil and/or refined product argue that a tariff is necessary to protect the energy security of the United States. Apprehension is expressed over the reduction in drilling activity that has occurred in the United States as the price of oil has fallen in the last year or two.[56] Supporters appear to be concerned that the United States will become vulnerable to a short run cutoff in oil imports. They argue that such a situation could arise because of the time

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[56] See, *e.g.*, the comments of Senators Domenici, Boren, and Bingaman in introducing the proposed Energy Security Act of 1986, *Congressional Record*, pp. S11954-S11956 (August 15, 1986).

needed to drill new wells and because of the absence of a sufficient number of existing wells to supply our needs during the cutoff.

A second facet of the energy security argument involves the quantity of U.S. oil reserves.[57] The concern here appears to be that insufficient exploration will be undertaken with low oil prices. As a result, it is feared that the U.S. reserve base will decline; and the U.S. will become more dependent on imported oil in the long run.

Below we consider, in turn, the desirability of using a tariff to promote additional exploration for reserves and of using a tariff to ensure that we have a sufficient level of crude production to withstand a temporary disruption in import supply. We suggest that a policy of keeping prices high to maintain our reserve base is self-defeating because high prices will encourage production, while its effect on exploration and development may be limited. Increased production from a fixed and limited supply of domestic reserves will reduce, not enhance, the remaining domestic reserves. Other policies that may not increase price, such as increased use of percentage depletion allowances, will still reduce domestic reserves. Moreover, if the key concern is that inadequate drilling will make the U.S. vulnerable to a short run cutoff in import supply, purchasing imported oil at current low prices and storing it for use in the event of a disruption is likely to be a less expensive alternative.

Why is Government Intervention Necessary?

Before examining the efficiency of specific forms of government intervention in the market for crude oil, we should consider the need for government involvement. What is the market failure that makes government intervention necessary? Why can we not rely on private consumers and producers to take the appropriate steps to limit their vulnerability from a cutoff of imports?

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[57] *Ibid.*

Government action is not necessary simply because oil prices may rise in the future. If oil consumers and producers expect oil prices to rise in the future, these expectations will be reflected in decisions involving purchases of equipment that use oil or in decisions concerning investments in additional drilling or exploration.

For example, a firm designing a new steam boiler will consider the likely future price of oil in deciding on the design to employ. If the firm's planners believe there is a significant probability that the price of oil will go to $27 per barrel during the life of the boiler, the firm will not construct a unit that is efficient at the current low price of oil but which would be highly inefficient at a price of $27. Rather, a boiler will be chosen that will minimize the expected costs of operating the boiler over its life.[58] The firm may even find it profitable to install a boiler that can switch from oil to another fuel in the event the price of oil rises.

Provided the firm will pay the true cost of any oil consumed in the boiler, the firm will have the correct incentives to install a boiler that makes efficient use of oil.[59] Similarly, in choosing a new heating system for his or her home or in purchasing a new

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[58] That is, in designing the boiler, the firm will consider operating costs at the current price of oil and how long they expect oil to remain at that price as well as the cost of operating at other prices for oil and the time during which each of those prices is expected to exist.

[59] As we note below, a problem can arise if the firm would not pay the true social cost of the oil in some or all periods of time. For example, a firm may build a boiler that uses more oil than is efficient if it believes that price controls would hold down its costs in the event of substantial increase in the price of oil. However, building such a boiler would be efficient only if oil would be available at a below-market price during periods of price controls. If price controls are accompanied by some form of rationing and the firm cannot acquire the oil needed to run the boiler, then the costs of building a boiler dependent on oil may be even greater than if no price controls are anticipated.

automobile, a consumer will consider what he or she expects the price of heating oil and gasoline will be in the future as well as the price that exists currently.

Decisions on whether or not to make additional investments in exploration for, and development of, new crude oil fields will similarly be dependent on expected future prices rather than current ones. The profitability of new exploration depends on the price that will be received for any oil that is discovered. However, that oil will only be brought to the market at some point in the future. For example, the Office of Technology Assessment has estimated that between 8 and 12 years would elapse between the time exploration in deep water off the California coast or in Alaska is begun and the beginning of production.[60] Further, once production is begun, it would continue for a considerable period of time -- up to 27 years in the case of Alaskan production.[61]

Thus, if prices are expected to rise in the future, producers will incorporate this information in their decision making and will engage in more exploration than would be profitable considering only the current price. A decline in the current price of oil will reduce exploration and/or drilling only to the extent that it causes producers to change their expectations regarding future prices.[62] Producers, as well as consumers, will engage in the optimal amount of exploration and drilling if they correctly

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[60] U.S. Congress, Office of Technology Assessment (1985), p. 119. Even in the Gulf of Mexico where much drilling has already occurred, it would take about two years to begin production.

[61] U.S. Congress, Office of Technology Assessment (1985), p. 120.

[62] For a more technical discussion of the decision to consume or produce oil in the face of pricing uncertainty, see Bohi and Montgomery (1982), especially chapter 4.

anticipate future prices and if the prices they will receive are equal to the social cost of oil.[63]

We also note that changes in future price expectations can cause wider fluctuations in exploration activity than would be predicted from a long term model. For example, if producers' expectations regarding future prices are adjusted downward, existing proven reserves may be more than sufficient to meet desired production levels for the next several years. As a result, exploration may be drastically reduced. However, as the existing stock of proven reserves is exploited, exploration will return to a somewhat higher level even if there is no change in future price expectations.

There are some indications that such a temporary fluctuation may be partially responsible for the extent of the decline in exploration activity since 1985. Between July and November 1986, the average price of crude oil, expressed in constant 1982 dollars, was $10.94 per barrel. While extremely low in comparison to prices over the preceding 12 years, the real price of oil was still approximately 50 percent higher than it had been between 1968 and 1972.[64] And yet, exploration in 1986 was at its lowest level since at least 1950.[65]

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[63] As with decisions to invest in oil consuming equipment, decisions to invest in additional exploration or drilling can be influenced by the belief that price controls may be imposed in the future. Further, while the inability to obtain sufficient quantities of oil during any price control period may mitigate the effect of the controls on consumption decisions, there will be no similar offset in the case of production decisions.

[64] See U.S. Department of Energy (1986c), p. 135 and U.S. Department of Energy (1987b), p. 91. Price comparisons are based the composite refiner acquisition cost of crude oil. The Implicit Gross National Product price deflator is used to adjust current prices.

[65] In 1986, 7,050 exploratory wells were drilled. The lowest number of such wells drilled in any year between 1949 and 1985 was 7,130 in 1971. Total footage drilled in exploratory wells was

Some may argue that oil consumers and producers do not correctly foresee the future prices of oil and that therefore government intervention is necessary because private decisions will be based on faulty price expectations. While many consumers and producers may have failed to foresee the large changes in oil prices in the last 15 years, this does not suggest a necessary role for the government. It is far from clear that government analysts have been more successful than private analysts in foreseeing the major price changes. Further, even if the government is better able to predict future prices, this would only suggest that the government should make its predictions public. It does not justify government interference with the private decisions made utilizing this information.[66]

Most economists would agree that the mere expectation of future increases in the price of oil does not justify market intervention. However, some arguments have been advanced that

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39.2 million feet in 1986. The next lowest level since 1950 was 40.2 million feet in 1950. During the last half of 1986, an average of 157 seismic crews were involved in exploration. This compares to a low of 195 crews in 1970. Finally, approximately 800 rotary rigs were being employed during the last half of 1986, compared to a low of 976 rigs during 1971. (U.S. Department of Energy (1986c), pp. 79 and 81, U.S. Department of Energy (1987b), p. 64, and Telephone conversation with Lawrence E. Mangen, U.S. Department of Energy, March 20, 1987)

The extremely low level of exploration in 1986 may also be at least partially the result of the increased cost of domestic oil exploration and production which is the natural result of the exhaustion of the easier to reach reserves.

[66] Indeed, governmental intervention may result in less efficient adjustment to possible future price increases. For example, such a policy can reduce the profitability of installing industrial boilers that can switch from oil to other fuels in the event of a disruption. Further, the policy unnecessarily raises current and expected future oil prices to all consumers including those who have already foreseen the possibility of future shocks and have adjusted their behavior accordingly.

may provide a stronger basis for intervention. For example, some studies have argued that price controls might be imposed again if there was a substantial increase in the price of oil and that this possibility can distort production and consumption decisions.[67] Various other studies have argued that the process of adjusting to sudden increases in oil prices may lead to increases in unemployment and in increased inflation.[68] While we have not attempted to evaluate these arguments in any detail, it is clear that, even if they do provide a theoretical rationale for intervention, there would be serious practical problems in any attempt to use a tariff to deal with these problems.[69]

Given the possibility that policy makers may conclude that intervention in oil markets might be justified, we now consider

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[67] See Wright and Williams (1982) who consider the need for government intervention where price controls are anticipated. These authors suggest that it would be virtually impossible for a government to credibly establish that price controls would not be imposed in the face of a substantial increase in the world price.

For additional discussion of this effect see footnotes 59 and 63 above.

[68] Some studies argue that have argued that petroleum and products that use petroleum as a significant input in their production processes compose such a large percentage of our total Gross National Product that a sudden change in the price of oil can impose macroeconomic costs. (See, *e.g.*, Bohi and Montgomery (1982), chapter 5, Broadman and Hogan (1986), Kline (1986), and National Petroleum Council's Committee on U.S. Oil & Gas Outlook (1986).)

[69] The optimal policy to deal with these costs may well involve different prices being charged to consumers and producers. For example, in some formulations of the costs of disruption, it is total consumption of oil that determines the disruption costs. In such a case, there is no justification for the increase in domestic production that would result from a tariff. In addition, imposition of a tariff will cause some level of disruption of its own as firms adjust to the increase in the price of oil. (See Bohi and Montgomery (1982), chapter 5.)

whether a tariff is a good policy tool to employ if intervention is to be undertaken.[70]

Imposition of a Tariff to Maintain Domestic Reserves

There are significant weaknesses in the argument that a tariff will promote energy security by encouraging exploration and thereby increase our crude oil reserves. First, it presumes that a tariff will encourage development more than extraction. Second, it ignores the fact that crude oil is a non-renewable resource. That is, there is only a limited supply of crude oil located under United States territory, and once this oil is extracted, we will either have to utilize alternative energy sources or rely totally on imported oil.

A tariff may have only a limited effect on exploration for new reserves because producers may not believe that current tariff policy provides much guidance as to what governmental policy will be a decade or more in the future.[71] Neither the Mandatory Oil Import Program of the 1960s -- which was intended to keep the price of oil up by restricting imports -- nor the price

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[70] In addition to the macroeconomic and price control arguments, it has also been argued that a tariff on oil could result in net benefits to the United States if the U.S. faces an upward sloping supply curve for petroleum imports. In this case, an "optimal" tariff might allow the U.S. to exploit monopsony power by reducing its demand for imports, thereby lowering the price paid foreign suppliers. While such an optimal tariff is theoretically possible, the results of our analysis suggest that any optimal tariff on crude oil and/or gasoline would be extremely small. (See Chapter II and the Appendix.)

[71] The same problem would appear to arise with other policies that are designed to encourage exploration by making production more profitable. For example, increasing the percentage depletion allowance or making it available to major producers as well as independents would encourage current production and thereby reduce the availability of reserves in the future. (See U.S. Department of Energy (1987a), pp. 77-78.)

controls program of the 1970s -- which was designed to keep the price down, lasted much more than 10 years.[72] As noted above, it is expectations about prices 10 to 35 years in the future that will determine the profitability of current exploration, particularly in frontier areas such as Alaska and off the California coast. Thus, while the imposition of a tariff may increase exploration activities in traditional oil production areas such as the Gulf of Mexico where production can commence within a couple of years of exploration, it may have much less effect on exploration in the frontier areas that are likely to have a large effect on the United States' future energy security.

In addition, given the limited supply of potential crude oil reserves, if energy security makes it desirable to have large domestic reserves at some point in the future, policy should be designed to *minimize* current production of domestic oil without discouraging exploration for new sources. By removing less from the fixed supply at present, more will be available for future use.

A tariff, however, does not minimize current extraction. Rather, production of domestic crude oil is expanded beyond what would occur if the market were permitted to operate without government interference.[73] As we discussed in Chapter II, we estimate that a $5 tariff on crude oil combined with a $5 tariff on gasoline would increase the production of domestic crude oil by 1.1 million barrels per day. Thus, this tariff plan reduces future domestic reserves at the rate of 1.1 million barrels per day. This increase in production is unlikely to contribute to future energy security. The same problem appears to hold for another policy currently being debated -- the expansion of the percentage depletion allowance allowed independent producers or making it once again available for major producers. It appears

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[72] As noted in chapter 3, the Mandatory Oil Import Program began in 1959 and was lifted in 1973. Price controls were in place from 1971 to 1981. (See p. 18 above.)

[73] The Department of Energy has observed that "An import fee is essentially a 'drain America first' program." (U.S. Department of Energy (1987a), p. 73)

that either of these policies would reduce future security by reducing reserves.[74]

Even if there is a valid concern with the level of exploration at low petroleum prices, it does not follow that a tariff is the best policy for addressing this concern. Rather, if something is to be done, we would suggest that serious consideration should be given to a subsidy for exploration activity as a less costly alternative to imposing a tariff.[75] While such a subsidy could introduce costs and distortions of its own, it would interfere with the market at only the exploration level. Exploration subsidies would not alter incentives to consume and would have smaller effects than a tariff on the incentive to produce. The consumer costs resulting from higher petroleum prices can be avoided. Similarly, by avoiding the excessive level of domestic production that results from a tariff, a subsidization policy would make a greater contribution to energy security.[76]

Use of a Tariff to Avoid Vulnerability to Short Run Disruptions

A tariff also appears to be an inefficient way of dealing with concerns about short run disruptions in import supplies similar to the embargo on shipments to the United States by the Organization of Petroleum Exporting Countries (OPEC) in late 1973 and early 1974.[77] In the first place, the likelihood of such disruptions resulting from actions of OPEC may be much smaller

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[74] U.S. Department of Energy (1987a), pp. 77-78.

[75] We are not recommending that exploration subsidies be adopted. Rather, we are merely noting the likelihood that they would be superior to a tariff.

[76] See U.S. Department of Energy (1987a), pp. 76-77, for a discussion of the costs and effects of some possible exploration subsidies.

[77] According to Kalt, the effects of the OPEC embargo begun in October 1973 were felt into the spring of 1974. (Kalt (1981), p. 115.)

than in the 1970s. There are two reasons for this. First, OPEC has had a history of problems in agreeing on the quantity of oil to be supplied by each member nation and in securing the compliance of its members with any agreement. While Saudi Arabia has been willing in the past to support the cartel price by reducing its own production levels, there are indications that it may not be willing to play this role for ever. Thus, OPEC may find it difficult to establish a non-competitive pricing scheme in the future.

Second, experience since the early 1970s has demonstrated that the demand for OPEC oil is sensitive to price in the long run. The world demand for crude oil is elastic in the long run.[78] Moreover, high prices for oil bring forth increased oil supplies from many non-OPEC countries.[79]

Even if there is a serious risk of a major oil shock and assuming that a tariff is capable of ensuring an adequate level of production in the future, it appears to be less-costly to acquire and store the oil needed to maintain an acceptable level of consumption in the event of a disruption.[80] The oil to be stored would be purchased at the low current price of oil. To understand why storage is superior to a tariff, it is necessary to

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[78] Pindyck (1979).

[79] In the ten year period following the initial oil price shock in 1973, for example, oil production in Mexico increased nearly five-fold from 23.3 million metric tons per year to 138.6 million metric tons. Production by the United Kingdom went from less than 50,000 metric tons per year to 111.4 million metric tons, while production in mainland China doubled and production in the Soviet Union increased by more than 40 percent. (See *Statistical Abstract of the United States, 1975*, pp. 851-852, and *Statistical Abstract of the United States, 1986*, pp. 851-852.)

[80] As discussed above, see pp. 40-42, a tariff may not contribute to energy security. However, we assume here that it will induce larger domestic production for the relevant period.

consider the costs incurred if either of these policies is employed.[81]

In Chapter II, we estimated the annual cost to society resulting from a tariff policy. We estimated that a tariff of $5 on both crude oil and gasoline would cost society between $3.6 and $3.8 billion per year. Every year a tariff is maintained, this cost is incurred. Thus, if a tariff is enacted to alleviate the costs of a disruption and the disruption does not occur until the fifth year a tariff is in place, the United States loses between $3.6 and $3.8 billion in each of the four years of non-disrupted supplies. Further, the cost of producing the additional oil during the disruption exceeds the current cost of purchasing oil on the world market.

A storage strategy would, however, impose costs of its own. First, there are costs incurred in preparing storage sites and maintaining them while the oil is being stored. Second, because oil is purchased currently for use in the future, there is an opportunity cost of not using the oil until an uncertain future date. The U.S. must borrow the money now and not receive the benefit or income from the oil until a crisis arises. Finally, it may not be possible to extract all of the oil from the storage facility when we want to use it. Thus, it may be necessary to purchase more oil than would be needed in a crisis, increasing the cost of a storage strategy. These costs are, of course, not incurred with a tariff.

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[81] In this discussion, we assume that the oil to be placed in storage is purchased directly. Some commentators have recently proposed that the Strategic Petroleum Reserves (SPR) be expanded by requiring importers of crude oil to contribute a portion of their imports to the SPR. (See, *e.g.*, "House Clears Budget for '88 of $1 Trillion", *Wall Street Journal*, April 10, 1987, p. 2.) The effects of such a policy would be more like those of a tariff than those of the storage strategy discussed here. In particular, the current price of oil would rise because importers would have to cover the cost of the oil contributed to the SPR. These increased prices would lead to significant costs to consumers, similar to those resulting from a tariff.

In order to compare the costs of these two approaches, we computed the yearly costs and benefits of meeting a hypothetical supply disruption with each strategy. The costs of the storage approach are based on the estimates of the Department of Energy.[82] Table 4.1 provides the results of that analysis. Costs are expressed in present value terms to allow the comparison of policies that require different levels of expenditure at different points in time.[83] The scenarios considered involve a one year disruption of oil supplies occurring in the fifth year or in the tenth year after the policy is implemented. Similar results are found if the disruption is assumed to occur at other points in time.

We assumed that the storage strategy involves enough oil to permit consumption to expand by 1.1 million barrels per day (bpd) during the year of the disruption.[84] This permits the same level of consumption during the hypothetical disruption as does a $5 tariff on both crude oil and gasoline since that tariff increases domestic production by 1.1 million bpd. Thus, we can compare

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[82] Telephone conversation with Mr. David F. Johnson, Director, Systems Planning and Analysis, Office of Strategic Petroleum Reserves, U.S. Department of Energy, March 3, 1987, and Letter to Mr. Gerald E. Grinnell, Acting Director, Office of Energy, Department of Agriculture, from John W. Bartholomew, Director, Office of Strategic Petroleum Reserve, dated February 6, 1987.

[83] If the real rate of interest is r, the present value of an expenditure of $x made n years in the future is equal to $\$x/(1+r)^n$.

[84] Using storage requires the purchase of approximately 413 million barrels of oil since it is necessary to have available 365 times the 1.1 million barrel daily increase in consumption if the disruption will last one year, and only about 97 percent of the oil stored can be recovered.

Table 4.1

PRESENT VALUE OF A TARIFF VERSUS STORAGE TO PREVENT A ONE YEAR SHORTFALL IN CRUDE OIL OF 1.1 MILLION BARRELS PER DAY (Billions of Dollars)*

A. Disruption Occurs in Year 5

Year	Using a Tariff	Using Storage
1	-$3.80	-$8.25
2	-3.65	-0.45
3	-3.45	-0.45
4	-3.30	-0.45
5	5.10	11.15
Total	-$9.10	$1.55

* The price of oil in the year of the disruption is assumed to be $35 per barrel. The benefits of storage during the disruption exceed the benefits of the tariff because the costs incurred in that year differ under the two policies. See text for other assumptions underlying these calculations.

Figures are presented to the nearest $50 million; and therefore totals may differ from the sum of the individual elements due to rounding.

Table 4.1 (Continued)

B. Disruption Occurs in Year 10

Year	Using a Tariff	Using Storage
1	-$3.80	-$8.25
2	-3.65	-0.45
3	-3.45	-0.45
4	-3.30	-0.45
5	-3.15	-0.40
6	-3.00	-0.40
7	-2.85	-0.35
8	-2.70	-0.35
9	-2.60	-0.35
10	4.00	8.75
Total	-$24.45	-$2.75

the costs of this storage plan with the costs of the $5 tariff on crude and gasoline.[85]

Costs are incurred in each non-disruption year. In the first year, the costs of storage are the costs of acquiring the necessary oil, plus a cost of $3.00 per barrel to prepare the storage. We assume that three percent of the oil placed into storage will be unrecoverable. In successive years, there is an annual maintenance cost of $0.20 per barrel plus a five percent real interest cost on the amount borrowed to purchase the oil.[86] The costs of the tariff are the social costs which were reported in Chapter II to be $3.8 billion per year. We also assumed a real rate of interest of 5 percent. Finally, the figures are based on the assumption that the world price of crude oil does not depend upon the quantity of oil purchased by the United Sates, though the results using the partial pass-through figures are virtually identical.

In the year of the disruption, there are benefits from having the increased production. The extent of these benefits depends

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[85] We note that the Strategic Petroleum Reserve currently contains 515 million barrels of oil, which is enough oil to supply all of the U.S.'s demand for imported oil for a period of about 100 days or to increase U.S. consumption by about 1.35 million barrels per day for a year. (See "Enjoy Now, Pay Later," *Time*, March 16, 1987.) This oil would presumably be available to help relieve the costs of a disruption in addition to the increased oil available as a result of either the tariff or the storage analyzed here.

[86] Similar results are found if higher interest rate and storage cost assumptions are made. For example, if the real interest rate is taken to be 10 percent, initial storage costs are assumed to be $5.00 per barrel and annual maintenance costs are assumed to be $0.50 per barrel, the present value of the cost of the storage strategy is $3.05 billion if the disruption occurs in year five. The present value of the cost of the tariff approach is $9.05 billion. If the disruption occurs in year 10, the present values are $9.55 billion for storage and $21.55 billion for the tariff.

on the price of oil during the disruption.[87] Table 4.1 is based on the assumption that the price will rise to $35 per barrel.[88] While the level of benefits is dependent on the assumed price during the disruption, the comparison of the storage and tariff strategies is not affected. If the price of oil exceeds $35 the benefits of each strategy will be increased by the same amount. If the price is below $35 the benefits will be reduced by the same amount.

As the table shows, increasing domestic production by 1.1 million barrels per day in order to provide energy security against a disruption five years in the future imposes costs that have a present value which exceeds the benefits during the disruption by more than $9 billion. This amounts to approximately $22.50 per barrel of increased consumption during the period of the disruption. In contrast, storing sufficient oil to expand consumption by 1.1 million barrels per day provides net benefits of $1.55 billion.

If the disruption does not occur until the tenth year after the strategy is implemented, the cost of using a tariff comes to $24.45 billion, or more than $60 per barrel. In this case, the costs of storage exceed the benefits, though the net cost of storage is considerably smaller -- $2.75 billion or approximately

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[87] The reported benefits for the storage approach in the disruption year is equal to the value of the stored oil less the cost of storing it from the previous year. The reported benefits for the tariff are the value of the increase in production less the cost of producing the oil. In each case, the value of the oil is assumed equal to the market clearing price. This results in an understatement of the benefits of both strategies, but does not distort the comparison between them.

[88] We assume that during the disruption the domestic price of crude oil is $35 for both the storage and tariff strategies. That is, we assume that the tariff is removed during the disruption. If the tariff were to be maintained during the disruption, the price would be higher with the tariff strategy with the result that the benefits of the strategy would be lower than estimated.

$6.80 per barrel of additional consumption. Thus, while storage is still a less expensive approach than a tariff, it would not be optimal to use either strategy to protect against the costs of a disruption if it was known that the disruption would not occur for 10 years. The costs of avoiding the disruption would be greater than the costs incurred during a disruption if no policy was implemented.[89]

Based on these examples, it appears that it would be substantially less costly to purchase oil on the world market and store it for use in the event of a short run disruption in import supply, than to impose a tariff to expand domestic production. Thus, to the extent that energy security involves meeting such short run disruptions, imposition of a tariff does not appear to be the most efficient policy to employ. The storage strategy also furthers the goal of maintaining domestic reserves by avoiding the excessive production from domestic reserves that would result from a tariff. This strategy appears preferable to a tariff all the way around.

Concerns About the Refining Sector

While some independent refiners have argued that tariffs are necessary if the United States is to maintain sufficient refining capacity to insure its energy security, we find little justification for this concern. Imports of gasoline are relatively small, amounting to less than six percent of consumption.[90] Further, because the United States refineries appear to be relatively energy intensive as a result of the high fraction of gasoline they

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[89] However, as we mentioned in note 84 above, our methodology understates the benefits of storage and of the tariff. Further, in considering the actual implementation of a storage strategy, one would not know when the disruption would occur; and if the disruption occurred earlier -- *e.g.*, in the fifth year, then storage would be efficient.

[90] See Appendix Table A.1, U.S. General Accounting Office (1986), p. 18, and U.S. Department of Energy (1986b), p. 49.

produce, we would expect the level of gasoline imports to fall if prices remain at their current lower level.[91]

Imposing a tariff in order to increase domestic output of gasoline would also be an extremely expensive technique for increasing refinery output. While imposition of a tariff of less than fifteen cents per barrel would eliminate U.S. imports of gasoline, we estimate that this would increase the output of U.S. refineries by only about 80,000 barrels per day. Since the increase in the price of gasoline that would follow from the tariff would cost consumers approximately $350 million per year, consumers would wind up paying almost $4,200 each year for each barrel increase in daily refinery output of gasoline. Of course, much of the increased cost to consumers is a transfer to refinery owners. However, the net social cost of the tariff, while only about $2.5 million per year, comes to more than $30 per barrel increase in refinery output. Furthermore, these figures understate the actual costs that would be incurred because they ignore the costs of collecting the tariffs and also ignore the costs that would arise from the complications discussed in Chapter III.

In conclusion, there does not appear to be much reason for current concern about the level of gasoline imports. Imports of gasoline do not account for a large portion of total gasoline consumption. Further, the costs of decreasing our reliance on imports through the imposition of a tariff appear to be extremely high.

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[91] See Tseng (1986). Our demand and supply equations imply that gasoline imports would fall from 400,000 barrels per day (bpd) in 1985 to 100,000 bpd if the price of crude oil remained at the $17 per barrel level for five years. By the last quarter of 1986, gasoline imports had fallen to approximately 260,000 bpd. (U.S. Department of Energy (1987b), p. 45)

An Oil Tariff As A Source of Revenue

The final justification for an oil tariff that we consider is the argument that a tariff is a good way to raise revenue to reduce the federal budget deficit. As with the other rationales, our estimates suggest that a tariff is an extremely costly way to achieve the desired objective. Table 4.2 provides figures on the cost of a tariff per dollar of revenue raised. Figures are provided for both the cost to consumers and for the cost to the U.S. economy. Of course, since our estimates suggest that a tariff on crude oil alone would lead to the elimination of all crude oil imports and similarly that a tariff on gasoline alone would eliminate all gasoline imports, these policies would not generate any revenue at all.

As is shown in Table 2.1, imposing a tariff of $5 on crude oil and $5 on gasoline would generate tariff revenues of about $6.6 billion per year. However, as Table 4.2 indicates, consumers would pay $2 in increased gasoline costs for each dollar of revenue raised. Taking out the portion of the $2 cost that are transfers to crude oil producers and to the government, and adding in the losses imposed on refineries, we see that this policy imposes an inefficiency or deadweight cost on the U.S economy of approximately $0.50 per dollar of revenue raised.[92]

The costs of using a tariff on oil imports to raise revenue appear to be quite high. At a minimum, the figures suggest that serious consideration should be given to finding a less-costly alternative before such a policy is adopted.

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[92] While a $10 tariff on both crude oil and gasoline raises more revenue than a $5 combined tariff, the cost per dollar revenue raised are even higher. Consumers would pay in excess of $3 per dollar of revenue raised, and the cost to the economy is close to a dollar for each dollar of revenue. The preceding analysis ignores any increase in corporate income tax or windfall tax revenues that result from the increased price of oil and the increase in profits of oil firms.

Table 4.2

COST TO CONSUMERS AND COST TO THE ECONOMY PER DOLLAR OF TARIFF REVENUE RAISED*

Tariff	Cost to Consumers	Cost to Economy
$5 on Crude	(a)	(a)
$5 on Gasoline	(a)	(a)
$5 on Crude Oil and on Gasoline	$2.00 - $2.10	$0.45 - $0.55
$10 on Crude Oil and on Gasoline	$3.15 - $3.85	$0.80 - $1.30

(a) No revenue is raised under these tariffs.

* These figures are based on estimated values in Tables 2.1 and Appendix Tables A-3, A-5, and A-7.

Conclusion

In conclusion, there are serious questions about the efficiency of using a tariff to achieve any of the goals advanced by its proponents. First, it is important to recall that government intervention in petroleum markets is not necessary just because prices might rise in the future. Individual consumers and producers of oil will make investment decisions that reduce oil consumption or increase production to reflect any higher prices expected in the future. Thus, before proceeding to impose a tariff or other restriction, proponents need to identify the reason action is needed.

Even if there were a need for governmental intervention, a tariff does not appear to be the best way to proceed. A tariff increases the rate at which our limited petroleum reserves are depleted and thus reduces remaining reserves in the future. If some action is to be taken, a subsidy of exploration for new proven reserves and/or the purchase and storage of additional quantities of crude oil are likely to be more efficient ways of meeting energy security concerns, depending on the specific concern to be addressed.

Regarding the need for protection of the domestic refining industry to insure its future viability, we note two things. First, the level of gasoline imports is relatively low and may well decline if the price of crude oil stays low. Second, a tariff is a very expensive device for obtaining a quite small increase in refinery output.

Finally, a tariff appears to be a very costly way of raising government revenue. The costs are high both to consumers and to society as a whole. In addition, if tariffs at the levels discussed in recent years are imposed only on crude oil or on gasoline, the likely result is no tariff revenues because they would lead to the elimination of all imports.

CHAPTER V

SUMMARY

This study has examined the effects of proposed tariffs to limit imports of crude oil and/or gasoline. It extends the standard welfare model used in analyzing tariffs to include both crude oil and gasoline, which is produced by refining crude oil. It also examines the history of oil industry regulation to gain some insight into the practical problems of imposing tariffs on the petroleum industry.

This analysis has led to the following findings:

(1) While a crude oil import tariff of approximately $3 or more per barrel would eliminate all imports of crude oil, it would cause substantial increases in gasoline imports. Tariff revenues will accordingly be zero, while the net social loss would be in the neighborhood of $4 billion per year.

(2) Any significant tariff on gasoline will make the U.S. totally self-sufficient in gasoline. Little benefit would result from such a tariff since tariff revenues would be zero. Moreover, since U.S. imports of gasoline is very small at present, the tariff would offer little protection to domestic refiners. The net cost of this tariff to the U.S. economy are small, but the cost to consumers amounts to at least $300 million per year, and may be as high as $5.9 billion.

(3) A $5 per barrel tariff both on gasoline and on crude oil may generate as much as $6.7 billion per year in additional government revenues. While such a tariff would provide some protection for crude oil producers, refiners would be made worse off as imports of gasoline increased from less than 5 percent of total consumption to more than one third of total consumption. Furthermore, the cost to consumers would be nearly $14 billion per year. The annual cost to society as a whole would be nearly $4 billion.

(4) While other studies have suggested that a U.S. tariff may have the beneficial effect of depressing world petroleum prices, our analysis suggests that this supposed advantage may prove to be illusory. We have estimated that the net social losses from the three tariff alternatives are at least as great when we assumed that foreign prices are dependent upon our demand for imports as when we assumed that world prices were independent of U.S. demand.

(5) In the course of designing and implementing a tariff, various parties will seek, and likely obtain, special exemptions. Such exemptions, whether for certain products, firms, or countries exporting to the United States, would be particularly valuable to the favored groups. However, tariff revenues would probably be reduced as a result, and administrative costs would likely be increased. Moreover, many of these special exemptions would encourage inefficient U.S. production of refined petroleum products and of other products. As a result, the U.S. would become less competitive in world markets. All of the above points suggest that the social costs of a tariff would be greater than our estimates. Similar costs are likely if other policies are used to aid the oil industry.

(6) A tariff is not an efficient way of promoting the security of U.S. crude oil supplies. First, the fear that oil prices may rise, perhaps precipitously, at some uncertain point in the future does not provide evidence of a market failure which would require governmental market intervention. Further, a tariff encourages current domestic production which will reduce reserves available in the future. If governmental action is needed to protect against future disruptions -- an assumption with which we do not agree -- storage of oil and subsidies for exploration and development of domestic reserves would appear to be superior policy alternatives.

(7) There is little reason to impose a tariff on gasoline imports in order to ensure that the U.S. has sufficient refining capacity in the future. Gasoline imports are a small

percentage of total consumption and a tariff would be a costly way to reduce this small level of imports.

(8) A tariff is an extremely expensive way to raise government revenues, substantially increasing the price of gasoline to U.S. consumers.

APPENDIX A

DEVELOPMENT OF ANALYTICAL MODEL

I. INTRODUCTION

This appendix sets out in detail the analytical model and results which are reported in Chapter II. It discusses in turn the choice of demand and supply elasticities used in the model, the derivation of the U.S. demand and supply functions, the calculation of equilibrium prices and quantities assuming full pass-through, the estimation of consumer and producer surplus, and the calculation of equilibrium prices and quantities assuming partial pass-through. In addition, the model's predictions of the impact of various tariff alternatives are presented and discussed in terms of prices and quantities, as well as consumer and producer surplus changes, tariff revenues, and societal losses. Finally, a sensitivity analysis is performed to determine the robustness of the model's implications to alternative parameter assumptions.

II. CHOICE OF DEMAND AND SUPPLY ELASTICITIES

In arriving at the estimates of gains and losses presented in this study, it was necessary to assume values for four different elasticities: the U.S. demand and the domestic supply elasticities for crude oil and gasoline. The relevant time horizon has been taken here to be approximately five years.

U.S. Demand Elasticity for Crude Oil

The existing literature provides limited insight into the likely magnitude of this elasticity. Many estimates are based upon some weighted average of the demand elasticities of the various products derived from crude oil. Because the U.S imports (and exports) many of these products, such a weighted average does not accurately reflect the characteristics of U.S. demand for crude oil. Accordingly, we have chosen to ignore such estimates in constructing an equation depicting domestic demand for crude oil. One study of U.S. demand empirically estimated a value of -.14 (MacAvoy, 1982), however, the author discounted this result and chose a value of -.04 short run and -0.4 long run on the basis of prior studies of world demand and because these values provided the best simulation of actual demand for the 1966-1972 period. One study (Moran, 1982) cited a survey by the Energy Modeling Forum of eleven "widely regarded energy models" in 1980 which yielded a reference case consisting of a long run demand elasticity of -.6 at a price of $27. While it is unclear whether the elasticities of some of these models may not have been influenced by estimates of refined product demand elasticities, it is reasonable to expect, given the manner in which such models are constructed, that the elasticity values were chosen in the end so as to track recent time paths reasonably well.

On the basis of this information, an elasticity value of -0.3 has been judged to be consistent with the assumed five year time horizon of this study.[1] In arriving at this value from the above cited studies, it was assumed whenever necessary that the long run is comprised of ten years, and that 70% of the adjustment to long run occurs within five years. This position is supported by the conclusions of MacAvoy (1982) that full adjustment occurs within ten

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[1] After performing a similar review of the literature, the authors of a recent study arrived at a value of -0.5 for a ten year time horizon. [See Broadman and Hogan (1987), Appendix.]

years, although two other studies (Griffin, 1979, and Adelman, 1982) conclude that the process may take considerably longer.

U.S. Supply Elasticity for Crude Oil

Numerous studies can be cited which suggest a likely value for this elasticity. First, Erickson (1968), in correcting Fisher's seminal work in this area, found this elasticity to be approximately 0.9, which compared favorably with Erickson & Spann's (1971) estimate of 0.83. Epple (1975), on the other hand, estimated the elasticity of supply of crude oil with respect to the prices of crude oil and natural gas together to be 1.87; presumably, the elasticity with respect to just the price of crude oil would be less. Indeed, Epple uses his model to bracket this elasticity between zero and 2.3, providing a best-guess figure of 0.93. Similarly, Bohi & Russell (1975) cited 1.0 as being the commonly accepted value for this elasticity. In contrast, an elasticity of supply of approximately 0.3 can be imputed from EIA/DOE's Demand Analysis System projections (DOE, 1986b) from 1985 through 1990. In MacAvoy's (1982) study previously cited, he found that in his simulation model a short run value of 0.2 and a long run value of 0.4 best tracked the actual supply of crude oil for the period 1973 to 1980.

A value of 0.55 is adopted for this study. This figure is obtained consistent with the same assumptions adopted above for the demand elasticity of crude oil.

U.S. Demand Elasticity for Gasoline

Considerable research has been conducted which has yielded various estimates of this elasticity. Dahl (1986) summarizes approximately seventy such empirical studies, classifying each as to both the technique (e.g., flow, stock, distributed lag) and the data (e.g., cross-section, time series) used. In the context of this classification scheme, she calculates average elasticity values which can then be roughly characterized as short run or long run. For example, flow-type models yielded average short run and long run elasticities of -.12 and -.59. For stock-type models, she reported -.29 short run, -.52 intermediate, and -1.12 long run. Distributed lag and non-stock-flow models yielded long run elasticities of -.69 and -.55, respectively. It should be noted that while many of the seventy or so studies surveyed by Dahl were international in their scope, no significant difference in the reported average elasticities result from excluding these studies. Bohi (1981) also surveyed numerous studies of gasoline demand and concluded that an appropriate estimate for the short run demand elasticity is -.2, while for the long run it would be at least -.7. A recent study by Yang & Hu (1984) employed a disequilibrium maximum-likelihood estimation technique to arrive at a presumably long run value of -.56.[2] Finally, a DOE (1985) report titled "Demand Analysis System Elasticities" finds the demand elasticity for gasoline to be -.29 after five years and -.50 after ten years.

For the purposes of this study, a value of -0.5 is assumed.

U.S. Supply Elasticity for Gasoline

Relatively little research has been conducted to estimate this elasticity, probably due to the conceptual problems associated with specifying a supply curve for one of several joint products. In one study by Richardson & Mutti (1976), a short run value of 1.28 was reported for all refined products, based (in some unspecified manner) on one or more prior empirical studies. Another study by Tsurumi (1980) estimated this elasticity to be 1.96 or 0.53, with or without (respectively) allowance for

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[2] For reasons discussed below, the elasticity estimate of Yang & Hu may be suspect. However, the inclusion or omission of this result is not decisive in the choice of an elasticity value here.

parameter shifts in 1973. Since the validity of the proposed parameter shifts is not defended, it is unclear which, if either, value is appropriate. In addition, Yang & Hu's (1984) disequilibrium analysis yielded a presumably long run value of 1.47 (controlling for the price of crude).[3] Since neither of the latter two studies appear to take into account price controls, these results may accordingly be suspect.

Fortunately, given the manner in which the demand function for crude oil and supply function for gasoline are constructed in this study, only one elasticity value is needed. That is, since the proportion of crude oil input to gasoline output is taken to be essentially constant, the elasticities of crude oil demand and gasoline supply become functions of one another. For example, if we assume the demand elasticity of crude oil to be -.3 as has been proposed above, the elasticity of gasoline supply becomes approximately 1.9 (controlling for the price of crude oil). Given the inherent flaws in the three studies cited above, they can provide us with only limited evidence as to whether this value is in fact appropriate or not. Nevertheless, the value would appear to fall within the broad range of values bounded by these studies.

III. DERIVATION OF U.S. DEMAND AND SUPPLY FUNCTIONS

The analysis in this study relies on a partial equilibrium, comparative static model of international trade. For simplicity, the model assumes linear demand and supply functions for the two products, crude oil and gasoline. Prices and quantities observed in 1985 are taken to be observations of points on the domestic demand and

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[3] One would expect that an elasticity which did not control for the price of crude oil input would be less than one which was estimated controlling for the crude oil price, cet. par.

supply curves. However the 1985 crude oil price of $27 per barrel is higher than what is expected to obtain in the foreseeable future. Therefore, a baseline initial equilibrium is instead constructed around a crude oil price of $17 per barrel. Since the price of gasoline generally rises and falls dollar for dollar with the price of crude oil in world markets, a corresponding baseline equilibrium price for gasoline is determined to be $10 less than the 1985 refinery gate level of $32 per barrel.[4] In addition, the elasticity values cited above are arbitrarily assigned to the points corresponding to this baseline equilibrium, since most empirical studies underlying these values were

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[4] Precedent for this assumption can be found in various places. For example, in the presentation of an oil import tariff proposal before Congress, a $4 per barrel tariff on crude oil was projected to raise gasoline prices by $.08 to $.10 per gallon, or equivalently, $3.36 to $4.20 per barrel. [See *Congressional Record--Senate,* S.2779, August 15, 1986, p. 11955.]

An examination of historical data provides a similar picture. In 1983, 1984, and 1985, crude oil prices were relatively stable, as were gasoline prices. Crude oil prices fell beginning in January 1986, and gasoline prices followed one month later. For the four months 1/86 to 4/86, crude oil prices averaged $.20 per gallon lower than the same period in 1985. For the four months 2/86 to 5/86, gasoline prices also averaged $.20 per gallon lower. [See U.S. D.O.E. (1986d).]

Finally, the Department of Energy's petroleum forecasting model forecast for 1990 assumes a crude oil price increase of $2 per barrel over that of 1985 and then predicts a gasoline price increase of $1.96 per barrel. [See U.S. D.O.E. (1985).]

conducted over periods in which petroleum prices were lower than those seen in 1985.[5]

The derivation of the equations for gasoline demand and crude oil supply is easily accomplished with the assumed elasticities and the 1985 price and quantity observations. On the other hand, due to the inter-relationship between demand for crude oil and supply of gasoline, the derivation of these two equations is considerably more complex, as is demonstrated below.

U.S. Supply of Crude Oil

In 1985, at a crude oil price of $27 per barrel, domestic producers supplied approximately 9 million barrels per day. If the elasticity of supply is taken to be .55 at the baseline price of $17 per barrel, then a crude oil supply equation can be found to be:

$$Q_C = 3.06 + 0.22P_C + 0.22t_C$$

where t_C is the tariff on crude oil imports.

U.S. Demand for Gasoline

In 1985, at an average refiners' selling price of $32 per barrel, the U.S. demanded approximately 6.85 million barrels of gasoline per day. Note that while this corresponded to a price of about $50 per barrel at the pump--the difference or margin being made up by taxes, transportation, and retailing expenses--we have chosen to formulate this analysis in terms of the price to the

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[5] For example, if the assumed gasoline demand elasticity of -0.5 is assigned to the gasoline price of $22 per barrel, then the demand elasticity at the 1985 price of $32 per barrel would be approximately -0.8.

refiner. For simplicity, it is assumed that this margin is unaffected by the levy of an import tariff, which ensures that estimates of change in consumer surplus will be identical regardless of which price is used. The only remaining issue in formulating a demand function is whether the chosen elasticity applies to the price received by the refiner or the price paid by the consumer. It seems reasonable that most elasticity estimates were made using the price paid at the pump, and since we are employing prices received by the refiner, this requires an adjustment to the demand elasticity. Thus, since the $22 price received by the refiner is 55% of the $40 paid by the consumer, the -0.5 elasticity (assumed above) is adjusted to a value of -.28. The equation for domestic gasoline demand is then found to be:-

$$Q_G = 10.05 - 0.10P_G - 0.10t_G$$

where t_G is the import tariff on foreign gasoline.

<u>U.S. Supply of Gasoline and Demand for Crude Oil</u>

The refining of crude oil in the U.S. (unlike most of the rest of the world) can be characterized by three generalizations: First, crude oil is demanded almost entirely as an input into refineries. Second, gasoline serves as the primary product of the refining process in that it has the greatest share (about 50%) and it is considered by domestic refiners to be the most profitable. Third, due to technological and economic factors, U.S. refineries tend to be operated so that the share of gasoline (as a percent of crude oil input) has remained relatively stable in recent years despite variation in crude oil and refined product prices. Presumably, refiners typically would not choose to lower the output share of gasoline due to its higher profitability relative to the other co-products, and cannot increase gasoline's share due to the prohibitively high costs of doing so, i.e., costs in the form of foregone revenues of sacrificed co-products, increased energy input costs, higher prices for better grades of crude oil, and new investment in more sophisticated refining capacity. These three generalizations permit us to assume that, for the U.S. over the relevant time horizon of this study, the ratio of the quantity of gasoline supplied to the quantity of crude oil demanded is some constant, k.[6] Accordingly, once a supply equation for gasoline is specified in terms of all relevant prices, then the corresponding demand equation for crude oil is specified as well.

Both the supply equation for gasoline and the demand equation for crude oil are assumed to be functions of the crude oil price, the crude oil tariff, the gasoline price, the gasoline tariff, plus some price, P_O, for a hypothetical composite co-product of the refiner:

$$Q_C^D = a - bt_C + ct_G - dP_C + eP_G + fP_O,$$

$$Q_G^S = kQ_C^D.$$

The coefficients of these two equations can then be identified with the following information:

As indicated above, the quantity of gasoline supplied is assumed to be a constant proportion, k, of the quantity of crude oil demanded. This proportion is taken to be

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[6] A recent study, Dahl (1981), estimated an elasticity for the response of gasoline's share to changes in the price of gasoline relative to those of its co-products. This elasticity provides support for treating the gasoline share as a constant. For example, it implies that in order for the share to increase from 50% to 51%, the price of gasoline would have to rise by 10% relative to other co-products. It is of interest that Dahl estimated a higher supply elasticity for Canada, explaining the result with the fact that Canada operates normally with a smaller gasoline share, which presumably implies that the technological costs of increasing gasoline's share would be smaller.

equal to that which is observed in the 1985 data, namely, .533.[7]

In the absence of price information for the composite "other co-product," it is necessary to make some provision for possible changes in this composite price. Accordingly, it is assumed here that the world price of other co-products changes in this analysis only in response to changes in the world price of crude oil. Since this composite co-product is assumed to be traded in a world market with no tariff protection afforded to U.S. producers, there is no divergence (as is seen for gasoline with a gasoline import tariff) between the U.S. price and the world price. Moreover, as indicated previously, the world price of gasoline changes dollar for dollar with the price of crude oil. Therefore, if one barrel of crude oil makes one barrel of refined product, if the shares of gasoline and other co-products are relatively stable, and if the profit of a refiner is invariant to changes in the price of crude oil (as one would expect in a competitive industry), then

$$\Delta P_C = m \cdot \Delta P_G + n \cdot \Delta P_O,$$

where (m + n) is approximately equal to one. Moreover, a \$1 increase in the price of crude oil, accompanied by a \$1 increase in the price of gasoline, would result in a \$1 increase in the price of the (composite) other co-product. That is, the change in P_O must be exactly equal to the change in P_C. Accordingly, it is assumed that the derivative of P_O with respect to P_C is one. With this substitution, the expressions listed above for the quantity of crude oil demanded and the quantity of gasoline supplied have as arguments only the world prices of (and U.S. tariffs on) crude oil and gasoline.

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[7] Average 1985 U.S. consumption of crude oil was 12 million barrels per day, while U.S. production of gasoline was 6.4 million barrels per day. [See U.S. D.O.E. (1986d).]

An unpublished DOE study (Tseng, 1986) provides information on how the marginal costs of U.S. refiners change as the price of crude oil increases by $5 increments from $10 to $15 to $20 per barrel. On the basis of this study, we have estimated that in the neighborhood of a $20 per barrel price for crude oil, the domestic supply price of gasoline increases by approximately $1.20 for each $1 increase in the price of crude oil input.[8] That is, when the price of crude oil (and consequently the price of other refined products) rises by a dollar, refiners will continue to demand the same quantity of crude oil and to produce the same quantity of gasoline only if the price of gasoline rises by $1.20. Therefore, the derivative of the supply price of gasoline with respect to the price of crude oil should equal 1.2. To apply this, take the derivative of the crude oil demand equation with respect to the price of crude oil, while holding the quantity of crude oil constant, yielding:

$$- d + e(\partial P_G/\partial P_C) + f(\partial P_O/\partial P_C) = 0.$$

Since the price of the co-products is assumed to be determined in the world market and $(\partial P_O/\partial P_C) = 1$, then

$$(\partial P_G/\partial P_C) = (d - f)/e = 1.2.$$

On the other hand, an increase in the price of crude oil which is not accompanied by an increase in the price of the refined co-products would require a larger increase in the price of gasoline for domestic refiners not to reduce the quantity of crude oil they demand and the quantity of product they supply. The value of this change, equal to d/e, can be determined from the fact that 0.533 barrels of gasoline are produced from each barrel of crude oil. In the case of a constant P_O, the refiner's revenues will increase by as much as his costs only if a one dollar

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[8] The results of a sensitivity analysis which varied this value from 1.1 to 1.3 are presented in Table A-16 of Section VIII below. In general, the model's results did not appear sensitive to this parameter's assumed value.

increase in the price of crude oil is accompanied by an increase in the supply price of gasoline equal to \$1/.533, or \$1.88. Since an increase in the domestic price of crude oil resulting from the imposition of a tariff will not cause the price of the co-products to rise, the derivative of the domestic supply price of gasoline with respect to the tariff on crude oil, or equivalently, b/e, must equal \$1.88.

Similarly, an increase in the domestic price of gasoline resulting from a tariff on gasoline would leave the price of crude oil and the price of other refined products unchanged. Thus, the derivative of crude oil demand with respect to a tariff on gasoline, i.e., the coefficient c, should equal the derivative with respect to the price of gasoline, i.e., the coefficient e.

As indicated previously, the demand elasticity for crude oil is assumed to be -0.3 for this study. However, this estimate does not control for changes in the price of gasoline or other co-products; that is, the empirical studies which led to this value typically involved regressions of price and quantity of crude oil without inclusion of any refined product price variables. Accordingly, such elasticity estimates capture the responsiveness of demand for crude oil to simultaneous changes in the price of crude oil and its refined products (since they typically move together). However, the crude oil demand equation as specified above has as arguments the price of crude oil as well as the prices of its products, so the elasticity value assumed is not simply a reflection of the coefficient on the crude oil price variable. This problem can be resolved by recognizing, as was done previously, that a change in the crude oil price is generally matched dollar-for-dollar by a change in the price of gasoline in the world market. Then, upon differentiating the demand for crude oil equation with respect to the price of crude oil, one obtains (- d + e + f). This, when multiplied by price and divided by quantity of crude oil, becomes the demand elasticity commonly estimated, which is then set equal to the assumed value of -0.3.

Finally, it is observed that in 1985 at a crude price of $27 per barrel and a gasoline price of $32 per barrel, 12 million barrels of crude oil were demanded and 6.4 million barrels of gasoline were supplied domestically.

The equation for the U.S. demand for crude oil can then be found to be:

$$Q_C = 12.53 - 2.41t_C + 1.29t_G - 2.41P_C + 1.29P_G + 0.87P_O.$$

However, since the price of other refined products, P_O, changes dollar for dollar with the world price of crude oil, we can combine the terms in P_C and P_O and rewrite the equation as:

$$Q_C = 12.53 - 2.41t_C + 1.29t_G - 1.54P_C + 1.29P_G.$$

Recalling that the supply of gasoline is simply 0.533 times the demand for crude oil, the equation for the supply of gasoline is then:

$$Q_G = 6.68 - 1.29t_C + 0.69t_G - 0.83P_C + 0.69P_G.$$

Baseline Equilibrium

The four demand and supply equations, when evaluated at the baseline prices of $17 per barrel for crude oil and $22 per barrel for gasoline, yield the equilibrium quantities which are used as a baseline throughout this study. These quantities are contrasted with actual 1985 quantities in Table A-1.

Note that as a result of the lower prices for crude oil, domestic production is decreased relative to 1985 while U.S. consumption is increased, resulting in a sizable jump in imports. For refiners, the decline in crude oil prices overwhelms the decline in product prices so that

TABLE A-1

BASELINE EQUILIBRIUM QUANTITIES
(million barrels per day)

	Actual 1985	Baseline
Crude Oil:		
Demand	12.0	14.6
Supply	9.0	6.8
Imports	3.0	7.8
Gasoline:		
Demand	6.8	7.9
Supply	6.4	7.8
Imports	0.4	0.1

production of gasoline actually increases more so than does demand, causing imports of gasoline to fall.[9]

IV. EQUILIBRIA WITH FULL PASS-THROUGH

In investigating the effect of the various tariff alternatives on domestic consumption and supply, it is necessary to first determine whether the tariffs will have any effect on the world prices of crude oil and refined products. Initially, it is assumed that there will be no appreciable effect, that is, that there is "full pass-through" of the tariff to the consumer. In a later section we consider the possibility that a tariff may lower the world price of the product, resulting in a price change to U.S. buyers which is less than the amount of the tariff. This scenario is referred to as partial pass-through.

In assuming full pass-through, the world prices for crude oil and gasoline are simply the baseline prices of $17 and $22 per barrel, respectively. Substituting the appropriate tariff value for t_c and/or t_G, the four equations are then solved simultaneously to determine the quantities. However, in some cases, the tariff is more than sufficient to choke off imports, so that domestic price rises less than the tariff amount. In these cases, equilibrium quantities are found by equating domestic demand and supply for the product in question. This yields the amount by which the domestic price rises, which (when

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[9]Petroleum prices in 1986 were in the neighborhood of the prices assumed for the baseline. Since a five-year adjustment was assumed for the elasticities used to arrive at the baseline quantities, one would not expect the 1986 and baseline quantities to be identical. Instead, 1986 quantities should be bounded by 1985 quantities and the baseline quantities, which is what is observed. In general, 1986 quantities represent approximately 15-35% of the adjustment necessary to attain the five-year adjustment assumed for the baseline equilibriums.

treated as the tariff value) is then used to solve the remaining two equations.

V. CALCULATIONS OF GAINS AND LOSSES

In determining the distributive impact of a particular tariff alternative, as well as the net societal benefit or cost, it is necessary to calculate changes in four surplus numbers in each case: the consumer surplus (in purchasing gasoline), producer surplus of crude oil producers, producer surplus of refiners, and tariff revenues to the government. The net societal gain or loss is then the sum of these four components. Since this sum is typically negative, it is often termed the deadweight loss or allocative inefficiency.

The calculation of three of the four components is relatively straightforward. For consumer surplus and for crude oil producer surplus, the calculation is simply the product of the change in price and the average quantity bought or sold. For example, in the upper panel of Figure I, crude oil producers are shown to supply Q_o^s at the initial price P_o, and to supply Q_1^s at the post-tariff price of P'. The change in crude oil producer surplus is then equal to area A. The effect on gasoline consumers is depicted in the lower panel of Figure I. Lost surplus for gasoline consumers arising from a higher gasoline price is equal to the sum of areas a, b, c, d, and e. On the other hand, tariff revenue, equal to the product of the tariff amount and the quantity of the product imported, would be given by the sum of the three areas, C and D in the upper panel and c in the lower panel, in the case of full pass-through.[10]

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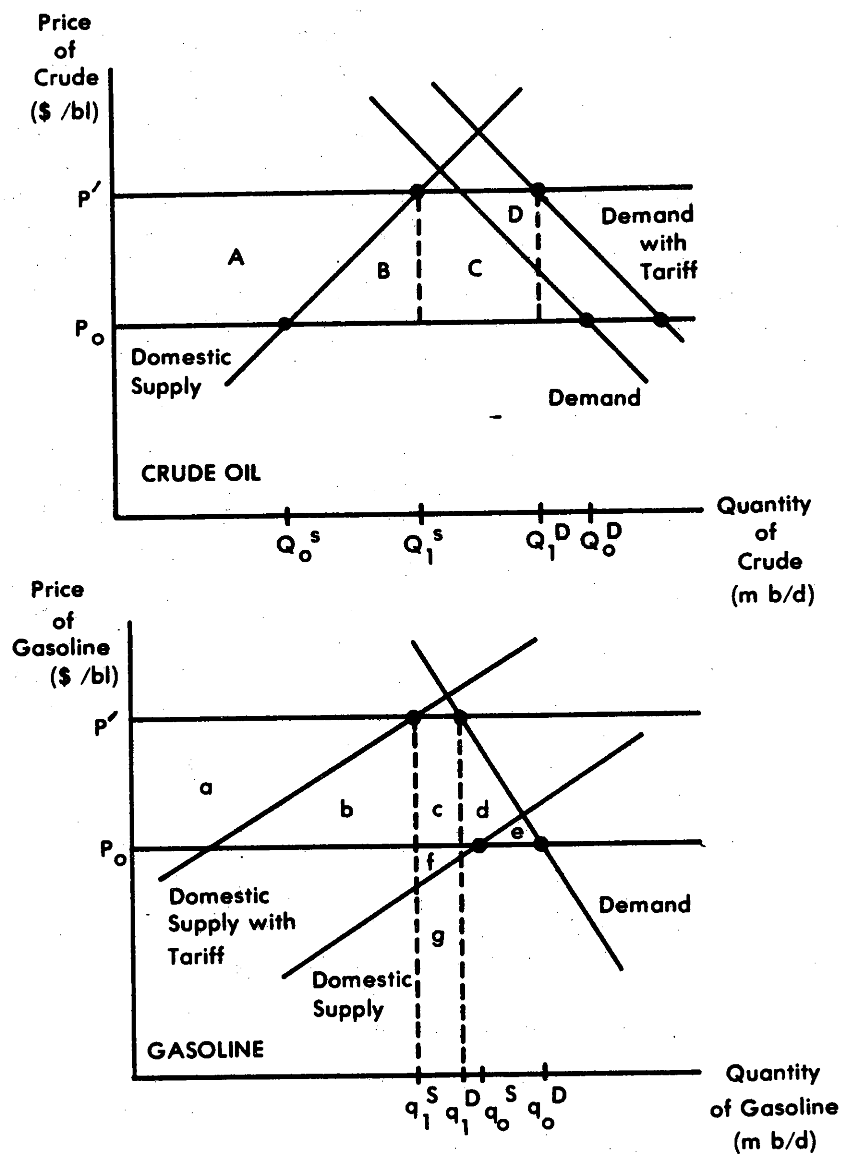
[10] In the case of partial pass-through, the graphic representation of tariff revenues would be complicated by the fact that the difference in price, pre- and post-tariff, would not be identically equal to the tariff amount. For example, if a tariff caused the world price of gasoline to decline, then

FIGURE I


Price of Crude ($ /bl)
P′
P₀
A
B
C
D
Demand with Tariff
Domestic Supply
Demand
CRUDE OIL
Q₀ˢ
Q₁ˢ
Q₁ᴰ
Q₀ᴰ
Quantity of Crude (m b/d)
Price of Gasoline ($ /bl)
P′
P₀
a
b
c
d
e
f
g
Domestic Supply with Tariff
Domestic Supply
Demand
GASOLINE
q₁ˢ q₁ᴰ q₀ˢ q₀ᴰ
Quantity of Gasoline (m b/d)

For gasoline producer surplus, the calculation is considerably more involved. This is so because of the joint product nature of the refining process and the fact that refiners are both consumers of crude oil and producers of gasoline (and other co-products). Consequently, one cannot rely on the standard consumer surplus calculation of the area beneath the demand curve in the crude oil market, nor on the standard producer surplus calculation of the area above the supply curve in the gasoline market, nor on the sum of these since this would involve substantial double-counting. Instead, a more complex formula must be developed which takes into account the peculiarities of the markets to be modeled.

Determination of the change in refiners' producer surplus is considerably simplified once it is recognized that refiner surplus is simply the profit which is earned. Thus, the change in surplus resulting from the imposition of some set of tariffs would be merely the resulting change in the profits earned by refiners. Further, in this analysis with two products, gasoline and "other co-products," profit can be affected by either changes in the revenue from the sale of the two products or from changes in the cost of producing the two products. For example, let the refiner's profit function take the form of:

$$\text{Profit} = (P_G+t_G)Q_G + P_O Q_O - (P_C+t_C)Q_C - V(Q_C) - F,$$

where prices are those determined in world markets, V is some variable cost in addition to that of crude oil, and F is fixed cost. Then, the change in refiners surplus is

$$\Delta PS = [\Delta(\text{Revenue})_{GAS} + \Delta(\text{Revenue})_{OTHER}] - [\Delta(\text{Cost})].$$

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the tariff revenue from imported gasoline would be more than the area, c, cited above, since the change in the domestic price of gasoline would be less than the tariff amount collected on each unit of imported gasoline.

Now, the change in revenue for each refined product can be expressed as

$$\Delta(\text{Revenue})_i = P^0_i \Delta Q_i + \Delta P_i Q'_i$$

where subscript i equals either G or O, superscript 0 indicates initial time period, and prime indicates subsequent time period. The change in costs resulting from a tariff is somewhat more complex, in that both crude oil and other variable input costs must be considered. Changes in the crude oil cost can be expressed in a manner similar to that shown above for the change in revenue, i.e.,

$$\Delta(\text{Cost})_{CRUDE} = P^0{}_C \Delta Q_C + \Delta P_C Q'_C$$

where initial and subsequent time periods are indicated as before. The change in other variable costs, i.e., $\Delta(\text{COST})_{NONCRUDE}$, is approximately the derivative of $V(Q_C)$ multiplied by the change in Q_C. Adding these two expressions yields the total change in cost of production.

In order to calculate the change in refiner surplus arising from the tariff alternatives under consideration, it is necessary to be able to evaluate both changes in revenue and in cost as is set out above. Since our analysis explicitly includes only the prices P_C and P_G but not the price of other products, P_O, the change in revenue from the sale of other refined products cannot be directly evaluated. However, the form of the analysis' gasoline supply curve does permit these revenue changes to be arrived at indirectly. Since gasoline and other refined products are produced as joint products, the supply schedule for gasoline is not simply a marginal cost function. Rather, the schedule reflects the marginal refining cost less the change in revenues derived from the sale of the other co-products. That is, upon differentiating the refiner's profit function with respect to the quantity of gasoline and solving for the price, one obtains the gasoline supply schedule:

$$P^S = [P_C^W + t_C + (\partial V/\partial Q_C)](\partial Q_C/\partial Q_G) - P_O{}^W(\partial Q_O/\partial Q_G),$$

where the superscript, W, indicates world market-clearing prices. The first term represents the marginal refining costs of a unit of gasoline, while the second term is the revenues of the co-products produced jointly with the additional unit of gasoline.

The area beneath this supply schedule between two values of Q_G is simply the change in the total cost of production less the change in the revenue from sale of the co-product, holding the price of crude oil constant. This area, denoted g in Figure I, is approximated by:

$$g = [P_C^W + t_C + (\partial V/\partial Q_C)](\Delta Q_C) - P_O{}^W(\Delta Q_O).$$

where g is negative (positive) as the change in the quantity of gasoline is negative (positive). The first term equals the sum of the first term of $\Delta(\text{Cost})_{CRUDE}$ plus the change in other (non-crude) variable costs, i.e., $\Delta(\text{COST})_{NONCRUDE}$. The remaining term is of course the change in revenues derived from the co-products arising from a change in the quantity of gasoline produced (holding the price of the co-product constant). Accordingly, upon performing these substitutions, one obtains:

$$\Delta PS = P_G^0\Delta Q_G + \Delta P_G Q_G' + \Delta P_O Q_O' - (g) - \Delta P_C Q_C'$$

$$= P_G^0\Delta Q_G + (\Delta P_G{}^W + t_G)Q_G' + \Delta P_O Q_O' - (g) - (\Delta P_C^W + t_C)Q_C',$$

where the superscript, W, indicates as before world (as opposed to domestic) prices. Note that there is no difference between domestic and world prices in the initial (pre-tariff) period, denoted by a superscript, 0.

Since the change in the price of the other co-products is assumed to change only with the world price of crude oil and only on a dollar-for-dollar basis, the change in P_O is identically the change in P_C. Furthermore, if one barrel of crude makes approximately one barrel of product, then $(Q_O - Q_C) = Q_G$, and

$$\Delta PS = P_G^0 \Delta Q_G + (\Delta P_G^W + t_G)Q_G' - (g) - \Delta P_C^W Q_G' - t_C Q_C',$$

or in the case of full pass-through,

$$\Delta PS = P_G^0 \Delta Q_G + t_G Q_G' - (g) - t_C Q_C'.$$

VI. CALCULATION OF PARTIAL PASS-THROUGHS

In attempting to relax the full pass-through assumption, one can obtain little guidance from the literature as to what the effect of a U.S. tariff on imports would be on world prices. One study (Gelb & Lazzarri, 1986) assumes somewhat arbitrarily that a reasonable pass-through would be in the range of 50% to 80% for both crude oil and refined petroleum products; that is, a \$1 tariff would cause world prices to fall by \$.20 to \$.50. It is not clear why the pass-through could be expected to be identical for crude oil and its products. Furthermore, the pass-through of a tariff on gasoline would be expected to depend on whether or not a tariff is levied simultaneously on crude oil, and vice versa. For these reasons, it is of particular value in this investigation of the effects of import tariffs to analytically estimate pass-through values which are consistent with the assumptions, the data, and the tariff alternatives of this study.

To accomplish this, the following procedure is followed: First, foreign demand and supply equations for the two commodities are developed in a manner consistent with the four U.S. equations. While U.S. quantities demanded and supplied are expressed in terms of P_C, P_G, t_C, and t_G, the foreign quantities are functions only of the two world prices. Second, total world demand is equated to total world supply for both crude oil and gasoline:

$$_{US}Q_i^D(P_C,P_G;t_C,t_G) + {}_fQ_i^D(P_C,P_G) = {}_{US}Q_i^S(P_C,P_G;t_C,t_G) + {}_fQ_i^S(P_C,P_G), \quad i = C,\ G.$$

Solving these two equations simultaneously yields the two prices in terms of the two tariff variables (which are of course exogenously determined). The pass-through can then be calculated by subtracting the pre-tariff price from the post-tariff price (which is the new world price plus the tariff), then dividing by the tariff amount. Full pass-through would be characterized by a value of one. In those instances where a tariff chokes off all imports, the solution must be found somewhat differently: First, equate the domestic demand and supply of the affected product; second, equate the foreign demand and supply of that product; third, equate the total world demand and supply of the other product. Then solve the three equations simultaneously for the two prices, as well as the effective tariff level for the product for which imports were choked off.

The formulation of the four foreign demand and supply functions which are used in this pass-through calculation has been based on the following assumed 1985 quantities for the rest of the world (in millions of barrels per day): quantity of crude oil demanded, 41.5; quantity of gasoline demanded, 8.7; and quantity of gasoline supplied, 9.1. Other relevant assumptions are discussed in turn below.

Foreign Demand for Crude Oil

Two major assumptions were made. First, the own price demand elasticity (not controlling for the price of gasoline) is the same as that of the U.S.[11] Second, the cross price elasticity with respect to the price of gasoline is half that of the U.S. This seems to be reasonable in light of the fact that outside the U.S. gasoline is not always viewed as the primary product of the refining process. In fact, gasoline has on average less than half the share of the yield of a barrel of crude oil than in the U.S.

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[11]See MacAvoy (1982) and Pindyck (1979).

The resulting equation for foreign demand for crude oil is:

$$Q_C = 54.40 - 3.10P_C + 2.21P_G$$

where the baseline quantity is 50.3 million barrels per day.

Foreign Supply of Crude Oil

The 1985 quantity of crude oil supplied is not taken as an observation of a point on the foreign crude oil supply curve. The OPEC cartel in the years prior to 1986 would appear to have successfully restricted output so as to maintain a high world crude oil price. Presumably, it was a partial or full collapse of the cartel which precipitated the dramatic fall in prices in 1986.[12] Accordingly, the 1985 price and quantity observation can be expected to lie on the foreign demand curve for crude oil but not on the foreign supply curve. Since in order to estimate partial pass-throughs, it is necessary to model the supply response of the foreign producers, it is assumed for this exercise that world petroleum markets are now essentially competitive and will remain so in the next five years.[13] In addition, it is assumed that, since (relative to the U.S.) foreign suppliers are low cost producers and

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[12] To some extent the success of OPEC in the later years resulted from Saudi Arabia's willingness and ability to restrict its share to compensate for excess production of other OPEC countries and the growth in non-OPEC production. This willingness apparently ended in 1985.

[13] One alternative is the assumption that OPEC will regain control once again and will maintain the price of crude oil in the face of any import tariff imposed by the U.S. This would be equivalent to the full pass-through scenario.

have a much greater ratio of reserves to actual production, the supply elasticity is twice that of the U.S. The baseline quantity supplied is furthermore taken to be 58.1 million barrels per day, or that amount sufficient to clear world crude oil markets.

The function for foreign supply of crude oil is then given by:

$$Q_C = -5.79 + 3.76P_C.$$

Foreign Demand for Gasoline

Since evidence was not found to suggest that the foreign demand elasticity for gasoline was significantly different from that of the U.S., the two demand elasticities were assumed to be equal.[14] The resulting demand function is:

$$Q_G = 12.67 - 0.12P_G$$

where the baseline quantity is 9.9 million barrels per day.

Foreign Supply of Gasoline

Since evidence was not found to suggest that the foreign supply elasticity of gasoline is significantly different than that for the U.S., this elasticity (controlling for the price of crude oil) was assumed to be equal to that assumed for the U.S. In addition, since foreign refiners (operating at a lower yield of gasoline per barrel of crude) have perhaps more latitude technologically in their choice of mix of refined products, the ratio of gasoline output to crude oil input was not assumed to be constant as was assumed for the U.S. Instead, it was simply assumed that the quantity of

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[14]See Dahl (1986).

gasoline supplied at the baseline gasoline price of $22 per barrel was sufficient to clear world markets.[15]

The resulting equation for foreign supply of gasoline is:

$$Q_G = 7.10 - 0.98P_C + 0.89P_G$$

with a baseline quantity of 10.0 million barrels per day.

VII. RESULTS WITH FULL PASS-THROUGH

Crude Oil Tariff

A tariff on crude oil imports, by effectively raising the price domestically, encourages the domestic production of crude oil and discourages both imports and U.S. consumption. In addition, by making crude oil more expensive to U.S. refiners, the tariff has the effect of decreasing domestic refining while encouraging the import of such petroleum products as gasoline. As Table A-2 indicates, a tariff as small as $3 per barrel is sufficient to reduce consumption by half while simultaneously encouraging domestic production enough so that imports fall to zero.

The demand for crude oil falls with an import tariff when domestic refiners cut production as a result of the increase in marginal costs and the lack of a compensating increase in the price at which they can sell their product.

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[15] Nevertheless, the results obtained in this study reflected little change in the share of gasoline in foreign production despite significant changes in the world price of gasoline relative to the price of crude oil and to the price of the other co-products. The share remained in the relatively narrow range of .20 to .22 in the five scenarios considered.

TABLE A-2

CRUDE OIL IMPORT TARIFF:
OUTPUT COMPARISON
(million barrels/day)

	Baseline	$5 Tariff*	$10 Tariff*
Crude Oil:			
Domestic	6.8	7.5	7.5
Import	7.8	0	0
Total	14.6	7.5	7.5
Gasoline:			
Domestic	7.8	4.0	4.0
Import	0.1	3.9	3.9
Total	7.9	7.9	7.9

*NOTE: Import of crude oil falls to zero as the domestic price rises to approximately $20.00 per barrel.

Accordingly, imports of gasoline (and presumably other co-products) rise significantly to a level comparable to domestic production.

Table A-3 displays the changes in surplus and tariff revenues that can be expected from any tariff on crude oil imports which is more than $3 per barrel. Note that consumer surplus is unchanged since the world price of gasoline is unaffected by the tariff in the full pass-through case. Tariff revenues are zero due to the fact that a tariff of $3 or more will effectively choke off imports. The deadweight loss to society then is the difference between the loss to refiners and the (smaller) gain to crude oil producers. This loss, in the order of $4.2 billion per year, is approximately 5% of baseline crude oil sales, with no compensating yield in the form of tariff revenues.

Gasoline Tariff

A tariff on the import of gasoline, by raising the price of gasoline to both consumers and refiners, has the effect of encouraging domestic production of gasoline while discouraging both its consumption and its import. In addition, in stimulating domestic refining, the tariff increases U.S. demand for crude oil at the (unaffected) world market price. Consequently, with no incentive for increased domestic production of crude oil, import of oil increases.

As Table A-4 indicates, a gasoline tariff of as little as $.10 per barrel would be sufficient to choke off all gasoline imports. (This occurs primarily because the initial baseline equilibrium involves a relatively insignificant level of gasoline imports, i.e., approximately 100,000 barrels per day.) The import of crude oil increases only marginally in this case.

Due to the relatively small change in the price of gasoline which a tariff would engender, there is little change in consumer and refiner surplus, as is shown in

TABLE A-3

CRUDE OIL IMPORT TARIFF:
SURPLUS CHANGES
($billions/year)

	$5 Tariff	$10 Tariff
Consumers:	0	0
Crude Oil Producers:	+7.7	+7.7
Refiners:	-11.9	-11.9
Tariff Revenues:	0	0
Net Societal Gain/Loss:	-4.2	-4.2

TABLE A-4

GASOLINE IMPORT TARIFF:
OUTPUT COMPARISON
(million barrels/day)

	Baseline	$5 Tariff*	$10 Tariff*
Crude Oil:			
Domestic	6.8	6.8	6.8
Import	7.8	7.9	7.9
Total	14.6	14.7	14.7
Gasoline:			
Domestic	7.9	7.9	7.9
Import	0.1	0	0
Total	7.9	7.9	7.9

*NOTE: Import of gasoline falls to zero as the domestic price rises to approximately $22.10 per barrel.

Table A-5. Of course, there would be no tariff revenues derived from the tariff and no change in the crude oil producer surplus. Neither are there any substantial benefits in the form of protection of domestic refining industry from foreign competition, since there was initially only limited imports. The net loss to society would be in the neighborhood of several million dollars per year.[16]

Combined Tariff

A tariff on both crude oil and gasoline would naturally combine elements of both of the two simple tariffs already discussed. Since the prices of both crude oil and gasoline are effectively increased domestically, total demand for both is decreased, although the decline in crude oil demand would be mitigated somewhat by the domestic refiners' output response to a higher selling price for gasoline. However, the domestic production of gasoline does not necessarily increase, since the simultaneous increase in the price of crude oil serves to shift the domestic supply curve for gasoline to the left. That is, while the higher gasoline price does result in a rightward movement along the gasoline supply curve, the increase in the crude oil price causes a leftward shift in

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[16] These results are somewhat obscured by the nature of the initial baseline equilibrium, i.e., one with negligible gasoline imports. For perspective, one can examine the impact of this tariff assuming a different baseline. Specifically, a lower demand elasticity for crude oil (and hence a lower gasoline supply elasticity) is assumed as part of the sensitivity analysis in Section VIII. The new baseline involves domestic gasoline production of 7.0 million barrels per day with imports of 0.9 million barrels per day. In this scenario, a $5 tariff on gasoline imports would choke off imports at $2.10, costing consumers $5.9 billion per year and benefitting refiners $5.8 billion per year. With no tariff revenues, the net social loss would be approximately 100 million dollars per year. [See Table A-14.]

TABLE A-5

GASOLINE IMPORT TARIFF:
SURPLUS CHANGES
($billions/year)

	$5 Tariff	$10 Tariff
Consumers:	-0.3	-0.3
Crude Oil Producers:	0	0
Refiners:	+0.3	+0.3
Tariff Revenues:	0	0
Net Societal Gain/Loss:	-0.0	-0.0

TABLE A-6

COMBINED CRUDE OIL AND GASOLINE IMPORT TARIFF:
OUTPUT COMPARISON
(million barrels/day)

	Baseline	$5 Tariff	$10 Tariff*
Crude Oil:			
Domestic	6.8	7.9	8.5
Import	7.8	1.1	0
Total	14.6	9.0	8.5
Gasoline:			
Domestic	7.8	4.8	4.5
Import	0.1	2.6	2.3
Total	7.9	7.4	6.9

*NOTE: Import of crude oil falls to zero when the domestic price of crude oil rises to approximately $24.80 per barrel.

the supply curve. As is indicated in Table A-6, it is thelatter shift which dominates when the combined tariff is equal for the two commodities. A $5 combined tariff causes a 40% decline approximately in the supply of gasoline. Since demand for gasoline decreases only modestly, imports rise from 0.1 to 2.6 million barrels per day. On the other hand, production of crude oil rises by 1.1 million barrels per day, while demand falls by 5.6 million barrels per day, causing imports to shrink dramatically.

A $10 tariff on both commodities effectively chokes off import of crude oil, since domestic production matches demand at a price which is only $7.80 above the world level. On the other hand, the domestic price of gasoline rises by the full $10, with the expected increase in domestic production and declines in both consumption and imports.

Table A-7 shows that consumers are the big losers with the combined tariff at either level, realizing losses in the order of $14 and $27 billion per year. While crude oil producers gain, refiners do not; integrated producers/refiners might still be expected to show a net gain, however. Tariff revenues are only slightly higher at the $10 level than at the $5 level due to the fact that a higher tariff serves to diminish the tariff base, namely, imports. In fact, the $10 combined tariff eliminates all imports of crude oil, as noted above.

The deadweight loss to society is appreciable, rising from $3.8 to $7.0 billion per year as the tariff level is increased from $5 to $10. These losses represent approximately 2.5% and 4.5%, respectively, of total baseline sales, and 55% and 80% of total tariff revenues.

TABLE A-7

COMBINED CRUDE OIL AND GASOLINE IMPORT TARIFF:
SURPLUS CHANGES
($billions/year)

	$5 Tariff	$10 Tariff
Consumers:	-13.9	-26.9
Crude Oil Producers:	+13.4	+21.9
Refiners:	-10.0	-10.6
Tariff Revenues:	+6.7	+8.5
Net Societal Gain/Loss:	-3.8	-7.0

NOTE: Net Societal Gain/Loss (or, equivalently, deadweight loss), which can be calculated by summing the gains and losses of consumers, producers and the government, may differ from this sum due to rounding.

VII. RESULTS WITH PARTIAL PASS-THROUGH

Crude Oil Tariff

The results of this tariff with full pass-through can be considered as a first step in understanding the outcomes with partial pass-through. That is, if under full pass-through a crude oil tariff causes imports of crude oil to drop dramatically, then one would expect under partial pass-through that the world price of crude oil would decline, ceteris paribus. Similarly, if a crude oil tariff under full pass-through causes imports of gasoline to increase, the world price of gasoline should increase. Moreover, as foreign production of gasoline increases to replace domestic production, foreign refiners can be expected to demand more crude oil which would have the effect of mitigating the fore-mentioned crude oil price decline. Indeed, Table A-8 shows that a $5 crude oil tariff causes the world price of crude oil to decline by a dime while the price of gasoline increases by $3.10. These price changes have second-round effects on the quantities demanded and supplied in the U.S. as is shown in Table A-9, however the effects are relatively subdued. Relative to the full pass-through case, the quantities of crude oil demanded and supplied domestically increase only marginally under partial pass-through, while the quantity of gasoline imported falls from 3.9 to 3.5 million barrels per day.

In Table A-10, it is interesting to note that even though this tariff alternative theoretically offers a means of extracting surplus from foreign producers (in the form of lower crude oil prices), the associated deadweight loss is actually higher in the partial pass-through scenario. This occurs primarily because the tariff causes the world price of gasoline to increase significantly, resulting in an $8.9 billion a year loss in consumer surplus. On the other hand, the gain to crude oil producers is almost offset by the loss to refiners. This would suggest that an integrated crude oil producer/refiner would be indifferent to this tariff alternative. In addition, since crude oil

Table A-8

Import Tariff Impact with Partial Pass-Through:
World Price Changes and Implied Pass-Throughs

	Effective Tariff*		Δ World Prices		Pass-through	
Tariff	t_C	t_G	P_C	P_G	Crude	Gas
$5 Crude	4.6	--	-0.1	+3.1	1.0	--
$5 Gasoline	--	0.2	-0.0	-0.1	--	0.6
$5 Combined	5.0	5.0	-0.4	+1.0	0.9	1.2
$10 Combined	9.0	10.0	-0.7	+1.3	0.9	1.1

* Effective Tariff may differ from actual tariff amount whenever a domestic price rise less than the tariff amount of the tariff is sufficient to clear the domestic market.

Table A-9

Tariff Impact with Partial Pass-Through: Price and Quantity Comparisons

	Baseline	$5 Crude ($t_C$=4.7)	$5 Gasoline	$5 Combined	$10 Combined ($t_C$=9.1)
Domestic Price:					
Crude oil	17.0	21.5	17.0	21.6	25.3
Gasoline	22.0	25.1	22.1	28.0	33.3
Q^S_C:					
U.S.	6.8	7.8	6.8	7.8	8.6
Foreign	58.1	57.7	58.1	56.7	55.5
World	64.9	65.4	64.9	64.6	64.1
Q^C_D:					
U.S.	14.6	7.8	14.7	10.8	8.6
Foreign	50.3	57.7	50.1	53.7	55.5
World	64.9	65.4	64.9	64.6	64.1

Table A-9--cont'd

Tariff Impact with Partial Pass-Through: Price and Quantity Comparisons

	Baseline	$5 Crude ($t_C$=4.7)	$5 Gasoline	$5 Combined	$10 Combined ($t_C$=9.1)
Q^S_G:					
U.S.	7.8	4.1	7.9	5.8	4.6
Foreign	10.0	13.0	10.0	11.3	11.9
World	17.8	17.1	17.8	17.1	16.5
Q^D_G:					
U.S.	7.9	7.6	7.9	7.3	6.7
Foreign	9.9	9.6	10.0	9.8	9.8
World	17.8	17.1	17.8	17.1	16.5
$k = (Q^S_G/Q^D_C)$:					
U.S.	.53	.53	.53	.53	.53
Foreign	.20	.23	.20	.21	.21
World	.27	.26	.27	.26	.26

TABLE A-10

CRUDE OIL TARIFF WITH PARTIAL PASS-THROUGH: SURPLUS CHANGES
($billions/year)

	$5 Tariff*	$10 Tariff*
Consumers:	-8.9	-8.9
Crude Oil Producers:	+11.9	+11.9
Refiners:	-11.6	-11.6
Tariff Revenues:	0	0
Net Societal Gain/Loss:	-8.6	-8.6

*NOTE: Import of crude oil falls to zero when the domestic price rises to approximately $4.60 above the world price of $16.90.

imports are choked off at $4.60 above the world price, i.e., less than the tariff level of $5 per barrel, there is no tariff revenue accruing to the government.

Gasoline Tariff

With full pass-through, a tariff on gasoline imports had little effect due to the fact that imports were choked off when price rose by a mere dime. A similar result obtains with partial pass-through when the domestic price rises by about a dime while the world price falls by a dime. The world price of crude oil, as well as the domestic and foreign quantities, are virtually unchanged, as is seen from Table A-9.

Table A-11 shows a loss in consumers surplus which is almost exactly matched by a gain in refiners surplus, just as was the case under the full pass-through. While the deadweight loss is nearly zero for this tariff alternative, the benefits are negligible as well. As before, not only is there no tariff revenue, there is little apparent need for protection of refiners from foreign competition, since gasoline imports account for a relatively small portion of domestic consumption.

Combined Tariff

Under full pass-through, a combined tariff had the effect of greatly decreasing imports of crude oil and significantly increasing imports of gasoline. Such changes can expect to have an effect on world market-clearing prices. As imports of crude oil decline, the world price of crude oil should fall. As imports of gasoline rise, the world price of gasoline should increase, and simultaneously foreign refiners should increase their demand for crude oil. The latter would have the effect of mitigating the fore-mentioned decline in the world price of crude oil. Indeed, it can be seen in Table A-8 that a combined tariff has the effect of marginally decreasing the world price of crude oil and increasing the world price of gasoline. Also

TABLE A-11

GASOLINE TARIFF WITH PARTIAL PASS-THROUGH: SURPLUS CHANGES
($billions/year)

	$5 Tariff*	$10 Tariff*
Consumers:	-0.3	-0.3
Crude Oil Producers:	-0.0	-0.0
Refiners:	+0.3	+0.3
Tariff Revenues:	0	0
Net Societal Gain/Loss:	-0.0	-0.0

NOTE: Import of gasoline falls to zero when the domestic price rises approximately $.20 above the world price of $21.90 per barrel.

in this table, it can be seen that the calculated pass-through for the combined tariff is very close to one for both commodities. This suggests that the prices, quantities, and associated surplus values should be approximately the same under the full and partial pass-through assumptions. This prediction is borne out in Table A-9 and in Table A-12 when compared back to Table A-5 and Table A-6. For example, full pass-through and partial pass-through assumptions yield consumer surplus losses of $13.9 and $16.7 billion dollars per year, respectively, at the $5 tariff level, and consumer losses of $26.9 and $30.3 billion at the $10 tariff level.[17] Similarly, the deadweight losses to society for full pass-through and partial pass-through are $3.8 and $3.6 billion per year, respectively, at the $5 tariff level, and $7.0 and $10.3 billion per year at the $10 tariff level.

VIII. SENSITIVITY ANALYSIS

In assessing the significance of the estimates of gains and loses calculated and reported above, it is useful to perform an analysis of the sensitivity of the model to alternative parameter assumptions. To this end, the

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[17] It should be noted that since this analysis does not take into account changes in consumer surplus associated with consumption of other refined products, the loss to consumers estimated here is somewhat overstated. Since with partial pass-through the world price of crude oil declines by $.40 to $.70 per barrel, the prices of refined products other than gasoline can be expected to decline to some extent. Given the likely decline in their prices due to the decline in the world price of crude oil, their share in U.S. consumption, and their market values relative to that of gasoline, it is unlikely that this overstatement would exceed $1 to $2 billion per year. Therefore, the bottom-line change in total social surplus would remain significantly negative for both tariff alternatives.

TABLE A-12

COMBINED CRUDE OIL AND GASOLINE TARIFF
WITH PARTIAL PASS-THROUGH:
SURPLUS CHANGES
($billions/year)

	$5 Tariff	$10 Tariff*
Consumers:	-16.7	-30.3
Crude Oil Producers:	+12.4	+23.3
Refiners:	-7.5	-11.2
Tariff Revenues:	+8.2	+7.9
Net Societal Gain/Loss:	-3.6	-10.3

NOTE: Import of crude oil falls to zero when the domestic price rises approximately to $9.00 above the world price of $16.30 per barrel.

following parameter values were varied in the context of the full pass-through model: the supply elasticity of crude oil, the demand elasticity of crude oil, the demand elasticity of gasoline, the derivative of the U.S. gasoline supply price with respect to the price of crude oil, and the baseline crude oil and gasoline price level. The three elasticities were each varied to a low of one half of the assumed level and to a high of twice the assumed level. That is, for example, if the demand elasticity of crude oil was originally taken to be 0.3, the model was recalculated for elasticity values of 0.15 and 0.6. The derivative of the U.S. gasoline supply price with respect to the price of crude oil was originally assumed to be 1.2. Since the model would be undefined at a value of 1.0, alternative values of 1.1 and 1.3 were used in the sensitivity analysis. Finally, the model was re-estimated with baseline prices corresponding to 1985 levels, i.e., with price of crude oil equal to $27 per barrel and price of gasoline equal to $32 per barrel.

As can be seen from Tables A-13 to A-17 which follow, the results reported previously, as well as the policy implications, are not significantly altered by the alternative parameter specifications. In no instance did the loss to either consumers or society as a whole change sign, and indeed in most instances there was little significant variation in either. In general, those instances in which either loss was significantly reduced arose because of a lower choke price for imports which thereby served to effectively limit the effectiveness (and costs) of the tariff.

This sensitivity analysis is particularly valuable in addressing concerns which might arise because of disagreement as to what is the appropriate value for a particular elasticity. For example, one reviewer believed that the value for the supply elasticity of crude oil would today be in the neighborhood of 0.2 or 0.3 (rather than 0.55). In Table A-13, the results which would be obtained with an elasticity value of 0.275 can be found under the heading of "Low." Note that while consumers surplus losses would be unchanged for each of the tariffs, the net social loss would be unchanged or decreased by a maximum of 20 percent. Even in the latter case the net social loss is significant at a level of $3.4 billion per year.

TABLE A-13
SENSITIVITY ANALYSIS: ELASTICITY OF SUPPLY OF CRUDE OIL

	Elasticity of Supply of Crude Oil Low	Middle	High
<u>$5 Tariff on Crude Oil, No Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$2.70	$2.95	$3.30
Gasoline	$0.00	$0.00	$0.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.4	0.7	1.2
Gasoline	-3.5	-3.8	-4.2
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.0	$0.0	$0.0
Gain to Crude Producers	$7.8	$7.7	$7.3
Gain to Refiners	-$11.2	-$11.9	-$12.7
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	-$3.4	-$4.2	-$5.4
<u>No Tariff on Crude Oil, $5 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$0.00	$0.00	$0.00
Gasoline	$0.10	$0.10	$0.10
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.0	0.0	0.0
Gasoline	0.1	0.1	0.1
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.3	$0.3	$0.3
Gain to Crude Producers	$0.0	$0.0	$0.0
Gain to Refiners	$0.3	$0.3	$0.3
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	(a)	(a)	(a)

(a) Net societal loss is less than $50 million.

	Elasticity of Supply of Crude Oil		
	Low	Middle	High
<u>$5 Tariff on Crude Oil, $5 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$5.00	$5.00	$5.00
Gasoline	$5.00	$5.00	$5.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.7	1.1	1.8
Gasoline	-3.0	-3.0	-3.0
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$13.9	$13.9	$13.9
Gain to Crude Producers	$14.6	$13.4	$11.6
Gain to Refiners	-$10.0	-$10.0	-$10.0
Tariff Revenues	$5.6	$6.7	$7.9
Net Societal Gain	-$3.5	-$3.8	-$4.5
<u>$10 Tariff on Crude Oil, $10 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$7.80	$7.85	$7.95
Gasoline	$10.00	$10.00	$10.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.0	1.7	2.8
Gasoline	-3.1	-3.2	-3.7
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$26.9	$26.9	$26.9
Gain to Crude Producers	$23.2	$21.9	$19.9
Gain to Refiners	-$10.3	-$10.6	-$10.9
Tariff Revenues	$8.1	$8.5	$8.9
Net Societal Gain	-$5.9	-$7.0	-$8.9

TABLE A-14
SENSITIVITY ANALYSIS: ELASTICITY OF DEMAND FOR CRUDE OIL

	Elasticity of Demand for Crude Oil Low	Middle	High*
<u>$5 Tariff on Crude Oil, No Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$4.85	$2.95	$1.85
Gasoline	$0.00	$0.00	$0.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.1	0.7	0.4
Gasoline	-2.8	-3.8	-6.1
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.0	$0.0	$0.0
Gain to Crude Producers	$13.0	$7.7	$4.7
Gain to Refiners	-$16.6	-$11.9	-$11.1
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	-$3.6	-$4.2	-$6.3
<u>No Tariff on Crude Oil, $5 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$0.00	$0.00	$0.00
Gasoline	$2.10	$0.10	$0.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.0	0.0	0.0
Gasoline	0.6	0.1	0.0
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$5.9	$0.3	$0.0
Gain to Crude Producers	$0.0	$0.0	$0.0
Gain to Refiners	$5.8	$0.3	$0.0
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	-$0.1	(a)	$0.0

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* With the high elasticity of crude oil demand, the U.S. is predicted to export 2 million barrels of gasoline per day if the price of crude oil remains at $22 for a period of five years.

	Elasticity of Demand for Crude Oil		
	Low	Middle	High
$5 Tariff on Crude Oil, $5 Tariff on Gasoline			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$5.00	$5.00	$4.40
Gasoline	$5.00	$5.00	$5.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.1	1.1	1.0
Gasoline	-1.4	-3.0	-5.8
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$13.9	$13.9	$13.9
Gain to Crude Producers	$13.4	$13.4	$11.8
Gain to Refiners	-$9.8	-$10.0	-$10.4
Tariff Revenues	$8.1	$6.7	$5.9
Net Societal Gain	-$2.2	-$3.8	-$6.7
$10 Tariff on Crude Oil, $10 Tariff on Gasoline			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$9.30	$7.85	$7.00
Gasoline	$10.00	$10.00	$10.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	2.0	1.7	1.5
Gasoline	-2.3	-3.2	-5.4
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$26.9	$26.9	$26.9
Gain to Crude Producers	$26.6	$21.9	$19.3
Gain to Refiners	-$14.7	-$10.6	-$9.8
Tariff Revenues	$7.9	$8.5	$8.9
Net Societal Gain	-$7.1	-$7.0	-$8.5

TABLE A-15
SENSITIVITY ANALYSIS: ELASTICITY OF DEMAND FOR GASOLINE

	Elasticity of Demand for Gasoline Low*	Middle	High
<u>$5 Tariff on Crude Oil, No Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$2.95	$2.95	$2.95
Gasoline	$0.00	$0.00	$0.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.7	0.7	0.7
Gasoline	-3.8	-3.8	-3.8
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.0	$0.0	$0.0
Gain to Crude Producers	$7.7	$7.7	$7.7
Gain to Refiners	-$11.9	-$11.9	-$11.9
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	-$4.2	-$4.2	-$4.2
<u>No Tariff on Crude Oil, $5 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$0.00	$0.00	$0.00
Gasoline	$0.00	$0.10	$1.55
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.0	0.0	0.0
Gasoline	0.0	0.1	1.1
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.0	$0.3	$5.1
Gain to Crude Producers	$0.0	$0.0	$0.0
Gain to Refiners	$0.0	$0.3	$4.7
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	$0.0	(a)	-$0.4

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* With the low value for the elasticity of gasoline demand, the U.S. is predicted to export 435,000 barrels of gasoline per day if the price of crude oil remains at $17 for five years.

	Elasticity of Demand for Gasoline		
	Low	Middle	High
<u>$5 Tariff on Crude Oil, $5 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$5.00	$5.00	$5.00
Gasoline	$5.00	$5.00	$5.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.1	1.1	1.1
Gasoline	-3.0	-3.0	-3.0
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$13.2	$13.9	$15.7
Gain to Crude Producers	$13.4	$13.4	$13.4
Gain to Refiners	-$10.0	-$10.0	-$10.0
Tariff Revenues	$6.2	$6.7	$7.9
Net Societal Gain	-$3.6	-$3.8	-$4.4
<u>$10 Tariff on Crude Oil, $10 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$7.85	$7.85	$7.85
Gasoline	$10.00	$10.00	$10.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.7	1.7	1.7
Gasoline	-3.2	-3.2	-3.2
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$26.0	$26.9	$29.4
Gain to Crude Producers	$21.9	$21.9	$21.9
Gain to Refiners	-$10.6	-$10.6	-$10.6
Tariff Revenues	$8.5	$8.5	$8.5
Net Societal Gain	-$6.0	-$7.0	-$9.4

TABLE A-16
SENSITIVITY ANALYSIS: DERIVATIVE OF GASOLINE PRICE WITH RESPECT TO CRUDE OIL PRICE

	Value of the Derivative		
	Low	Middle	High
<u>$5 Tariff on Crude Oil, No Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$1.55	$2.95	$4.25
Gasoline	$0.00	$0.00	$0.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.3	0.7	0.9
Gasoline	-4.0	-3.8	-3.7
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.0	$0.0	$0.0
Gain to Crude Producers	$3.9	$7.7	$11.3
Gain to Refiners	-$8.2	-$11.9	-$15.5
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	-$4.2	-$4.2	-$4.2
<u>No Tariff on Crude Oil, $5 Tariff on Gasoline</u>			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$0.00	$0.00	$0.00
Gasoline	$0.05	$0.10	$0.15
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	0.0	0.0	0.0
Gasoline	0.1	0.1	0.1
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$0.1	$0.3	$0.4
Gain to Crude Producers	$0.0	$0.0	$0.0
Gain to Refiners	$0.1	$0.3	$0.4
Tariff Revenues	$0.0	$0.0	$0.0
Net Societal Gain	(a)	(a)	(a)

	Value of the Derivative		
	Low	Middle	High
$5 Tariff on Crude Oil, $5 Tariff on Gasoline			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$4.10	$5.00	$5.00
Gasoline	$5.00	$5.00	$5.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.1	1.1	1.1
Gasoline	-3.7	-3.0	-2.0
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$13.9	$13.9	$13.9
Gain to Crude Producers	$10.8	$13.4	$13.4
Gain to Refiners	-$7.6	-$10.0	-$10.3
Tariff Revenues	$5.9	$6.7	$8.2
Net Societal Gain	-$4.7	-$3.8	-$2.5
$10 Tariff on Crude Oil, $10 Tariff on Gasoline			
Change in Domestic Price of (Dollars per barrel)			
Crude Oil	$6.65	$7.85	$8.95
Gasoline	$10.00	$10.00	$10.00
Change in Domestic Production of (Millions of barrels per day)			
Crude Oil	1.5	1.7	2.0
Gasoline	-3.4	-3.2	-3.1
Welfare Analysis (Billions of dollars per year)			
Cost to Consumers	$26.9	$26.9	$26.9
Gain to Crude Producers	$18.3	$21.9	$25.4
Gain to Refiners	-$6.9	-$10.6	-$14.1
Tariff Revenues	$8.9	$8.5	$7.9
Net Societal Gain	-$6.6	-$7.0	-$7.6

TABLE A-17
SENSITIVITY ANALYSIS: WORLD PRICE OF CRUDE OIL

	Pc=$17 Pg=$22	Pc=$27 Pg=$32
$5 Tariff on Crude Oil, No Tariff on Gasoline		
Change in Domestic Price of (Dollars per barrel)		
Crude Oil	$2.95	$1.15
Gasoline	$0.00	$0.00
Change in Domestic Production of (Millions of barrels per day)		
Crude Oil	0.7	0.3
Gasoline	-3.8	-1.5
Welfare Analysis (Billions of dollars per year)		
Cost to Consumers	$0.0	$0.0
Gain to Crude Producers	$7.7	$3.8
Gain to Refiners	-$11.9	-$4.4
Tariff Revenues	$0.0	$0.0
Net Societal Gain	-$4.2	-$0.6
No Tariff on Crude Oil, $5 Tariff on Gasoline		
Change in Domestic Price of (Dollars per barrel)		
Crude Oil	$0.00	$0.00
Gasoline	$0.10	$0.55
Change in Domestic Production of (Millions of barrels per day)		
Crude Oil	0.0	0.0
Gasoline	0.1	0.4
Welfare Analysis (Billions of dollars per year)		
Cost to Consumers	$0.3	$1.5
Gain to Crude Producers	$0.0	$0.0
Gain to Refiners	$0.3	$1.4
Tariff Revenues	$0.0	$0.0
Net Societal Gain	(a)	-$0.1

	Pc=$17 Pg=$22	Pc=$27 Pg=$32
$5 Tariff on Crude Oil, $5 Tariff on Gasoline		
Change in Domestic Price of (Dollars per barrel)		
Crude Oil	$5.00	$3.60
Gasoline	$5.00	$5.00
Change in Domestic Production of (Millions of barrels per day)		
Crude Oil	1.1	0.8
Gasoline	-3.0	-1.2
Welfare Analysis (Billions of dollars per year)		
Cost to Consumers	$13.9	$12.1
Gain to Crude Producers	$13.4	$12.3
Gain to Refiners	-$10.0	-$3.7
Tariff Revenues	$6.7	$2.1
Net Societal Gain	-$3.8	-$1.4
$10 Tariff on Crude Oil, $10 Tariff on Gasoline		
Change in Domestic Price of (Dollars per barrel)		
Crude Oil	$7.85	$6.05
Gasoline	$10.00	$10.00
Change in Domestic Production of (Millions of barrels per day)		
Crude Oil	1.7	1.3
Gasoline	-3.2	-0.9
Welfare Analysis (Billions of dollars per year)		
Cost to Consumers	$26.9	$23.2
Gain to Crude Producers	$21.9	$21.3
Gain to Refiners	-$10.6	-$2.9
Tariff Revenues	$8.5	$1.3
Net Societal Gain	-$7.0	-$3.5

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