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OIL IMPORTS: AN ASSESSMENT OF BENEFITS AND COSTS

Body of Report

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1.0 INTRODUCTION TO THE SOCIAL COSTS OF OIL IMPORTS

The levels of oil production, imports, and consumption raise concerns because they may have undesirable side effects which their market prices do not signal to consumers. Underlying this possible excess of social cost over market prices is the possibility that domestic and/or world markets for oil may be subject to market failures.[1]

This report reviews the full social benefits and costs of oil imports. As discussed further in Section 2.0, it is generally accepted that the social benefits of oil imports equal their private benefits (i.e., there are no significant *benefit* spillovers from importing). The benefits of oil imports at the margin are thus believed to be represented accurately by oil's market price. Accordingly, this document focuses its attention on costs. It surveys the conceptual issues surrounding the social costs of oil imports and offers a range of quantitative estimates of what those may be. It would be premature to conclude that, for example, the full social cost of oil is so many dollars and cents per barrel higher than the market price. The diversity of professional opinion neither supports nor justifies such confidence or precision at this point. However, review of the components which various experts believe to comprise the full social cost can clarify why opinions differ and help foster the discussion which may lead to improved consensus.

Oil is a commodity, but it possesses characteristics different, at least in degree, from other common commodities such as grains or metals. First, in common with most mineral commodities, it must be taken from where it is found--it cannot be grown or raised under suitable conditions. However, oil is extraordinarily concentrated in small parts of the world. Some 30 percent of current world production and over 60 percent of known reserves are located in the Persian Gulf region (U.S. DOE 1994:287), an area whose political and cultural instabilities are exacerbated by the opportunities represented by its vast oil wealth. This locational circumstance introduces possibilities for monopolistic (or, technically speaking, oligopolistic) behavior in the world oil market. Second, in conjunction with the locational concentration of oil reserves, the world's flexibility in substituting away from oil as a fuel has been more limited than is the case with most other mineral products. For other minerals, varying alloy proportions, production methods, and even synthetic substitutes are viable options. Third, the concentrated sources and limited substitutability away from oil in modern, industrial economies may combine to leave nations vulnerable to serious adjustment problems when faced with supply shocks. Fourth, all stages of the oil fuel cycle--extraction, refining, delivery, and final use--impose unintended, but nonetheless undesirable, impacts on the environment, ranging from oil spills to automobile exhaust.

These characteristics can contribute to a departure of the full social cost of oil from the price paid for a delivered barrel of oil or for a gallon of gasoline at the retail pump. The unaccounted social costs may include problems associated with noncompetitive markets (e.g. higher prices paid to noncompetitive suppliers); losses due to the risk of oil price shocks; environmental and health externalities; and military program costs. Some of these differences between private and social costs derive from oil production (e.g., some environmental disturbances in oil fields), others from consumption (e.g., automobile emissions or the exposure of the economy to shocks), and some may

[1] The term market failure has been standard in the economics discipline since Bator [1958] for describing conditions in which the market outcome is inefficient, i.e., is not Pareto optimal [Cornes and Sandler 1986:17].

derive explicitly from imports (e.g., the possibility of excess international wealth transfers[2] through cartel rent). Some are difficult to assign to a single activity. The interest here is in costs which vary directly with imports.

Although not technically correct, many analysts place all potential market failures and their associated costs under the heading of "externalities." "Externality" has become a convenient shorthand for any and all market failures that cause a deviation of full costs or benefits from price, and that may call for some type of government intervention. Unfortunately, lumping all market failures under one heading masks the sources and types of potential costs associated with oil production, imports, and consumption. More importantly, it blurs the types of government actions that can be taken to either offset the impacts of these market failures or directly correct the sources of the failures. Given this caveat, the study adopts the commonly used, broad definition of externality.

1.1 Study Focus on Imports

This report focuses on oil imports rather than consumption or production, not because imports *per se* are presumed to have higher social costs than consumption, but because imports are of more immediate policy interest for the Domestic Natural Gas and Oil Initiative. U.S. oil imports have grown substantially over the last decade, and are expected to climb to 60 percent of consumption by 2010. In general, free trade is highly beneficial to U.S. society, as is the use of oil. However, in cases where the market for a commodity is not fully competitive, is subject to price shocks and physical interruption, and may involve social costs not borne by the users of the commodity, the magnitude of trade, in addition to consumption and production, could be a concern.

Consumers will buy or import oil until the benefits of the last barrel bought by the last or "marginal" buyer are equal to its price.[3] However, at the margin, the "true" cost of oil imports may be higher than the price because of possibilities such as the influence of Organization of Petroleum Exporting Countries (OPEC) on world oil markets, price spikes from oil supply disruptions, or environmental damage from the importation of oil. The difference between the true cost of oil imports and the market price of oil is called the oil import premium.

This study has three purposes:

- to identify the possible social costs of oil imports that are not included in the price paid by consumers;
- to discuss the possible size of these costs; and
- to highlight the reasons for differences in cost estimates.

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[2] It is important to stress that the term "excess wealth transfer" is not intended to invoke a neomercantilist obsession with avoiding trade. To the contrary, free trade under competitive conditions increases social welfare. Rather the concern here is with transfers beyond the actual resource costs of the commodity, i.e. beyond that which would occur under competitive conditions. The term wealth (or income) transfer is in common use in the oil economics literature [e.g. Bohi and Toman 1993 or Eastwood 1992] when discussing the full costs of oil.

[3] At the margin, private benefits must equal the price, otherwise no purchase would be made if the benefits were too low, or more would be purchased if the benefits were more than the price.

Accordingly, the report identifies underlying conditions which appear critical to differences of opinion regarding the full social costs of oil imports and presents estimates of the per-barrel cost premiums which would be associated with those conditions.

Most of the analysis and debate about social costs of oil imports has centered on whether significant costs arise from noncompetitive market structures and oil price shocks. Non-competitive costs are those associated with monopoly or oligopoly power among producers and those involving monopsony power among certain importing countries. Disruption costs include possible social costs deriving from the difficulties an industrial economy experiences in preparing for or adjusting to large oil price shocks. With a subject as extensive as the economics of oil, it is to be expected that scholars and other experts may reach different conclusions regarding features of oil markets. While diverse research on some topics in the economics of oil has led to a broad consensus, if not unanimity of opinion, other important topics, including elements of the social cost of imports, continue to experience some sharp differences of professional opinion. *Much of the current diversity of opinion can be attributed to differing assessments of the character of competition in the world oil market, of the volatility of that market, and of the consequences of volatility.* For example, while some scholars find little persuasive evidence that the world oil market is at all close to being competitive, and have even calculated numerically what they believe to be the monopoly rent in the world oil price, others find little persuasive evidence that market power is being exercised by suppliers. The significance of these disagreements is that different characterizations may lead to quite different estimates of costs, and an inappropriate choice of policy could be very expensive. In deference to the variety of expert opinion on oil's social costs, we use the terms *potential cost* or *potential social cost*.

1.2 Overview of the Study

Section 2.0 introduces several concepts involved in the definition and measurement of the social costs of oil imports. First, there is the interdependence among total consumption, imports, and domestic production, which can create confusion when attempting to isolate the incremental costs of imports alone. Second, the base against which costs are measured must be specified because different choices of base will yield different assessments of costs. Third, closely associated with the choice of base, marginal cost concepts may be used to inform different types of policy decision. Fourth is the concept of an optimal oil import premium, or the difference between the social cost and the market price of imported oil when the volume of imports is at its socially optimal level. Finally, the concepts of the world oil market's competitive structure and volatility, or susceptibility to major supply disruptions, are presented in a two-dimensional continuum which facilitates identification of the grounds for several important differences of expert opinion regarding social costs of oil imports.

Section 3.0 discusses the social costs an importing country may experience as a consequence of suppliers exercising market power--technically a condition of oligopoly or cartel but commonly called monopoly power in the literature--and the possibilities that relatively large buyers may be able to exert influence over the price of a commodity which they buy--called monopsony power. Monopsony power need not be used even if it is possessed, but in the presence of the exercise of monopoly power by a seller, some exercise of it may be justified as a corrective measure. Nevertheless, it is possible that strategic or noneconomic considerations might dictate restraint in using monopsony power even in such circumstances. In the oil market, both supplier-cartel power and U.S. buyer monopsony power together are required to jointly motivate and enable the partial recovery of cartel rents. In this case, the recoverable cartel rents comprise a long-run component of the import premium.

Section 4.0 reviews a number of social costs which may arise through the limitations of an industrial economy in adjusting smoothly and rapidly to a sudden shock in oil supply. The magnitude, and even the existence, of most of these components of social costs of oil imports have been questioned in recent literature despite widespread, apparent evidence of those costs. This chapter reviews the diversity of reasoning used to arrive at the different conclusions.

Section 5.0 presents a series of numerical estimates of the oil import premium deriving from the potential costs of non-competitiveness and supply shocks, under a range of circumstances. This controlled construction of additive components facilitates identification of the relative quantitative importance of different sources of social costs and the sources of different opinions about the size of overall costs.

Before embarking on the remainder of the report, we offer a precis of conclusions.

- While the approach used in this study identifies different estimates of the premium associated with oil imports, it does not indicate preferred methods or policies for improving social efficiency. For example, diplomatic options could be effective substitutes for strictly economic policies. Few policies are costless, and the costs and benefits of policies should be compared to the magnitudes of problems they are intended to alleviate to see if an improvement actually can be made.

- Virtually all of the identified components of the oil import cost are subject to disputes regarding their validity and to uncertainty regarding their magnitude.

- The principal direct effects of an import reduction would follow from its ability to reduce the world price of oil in the face of noncompetitive supply, and from reducing the quantity of oil which is subject to higher import costs during a disruption. If world oil supply is deemed to be not subject to substantial exercise of market power and stable, then the United States has no motive to take this action.

- Although there is a debate about the competitiveness of world oil supply, there is empirical evidence available that supports viewing the Organization of Petroleum Exporting Countries (OPEC) as an imperfect cartel rather than an association of competitive producers. The *behavior* of oil prices, as contrasted to their level, is also not well explained by exhaustible resource theory. The most common view in the literature is that the cost of oil above its marginal extraction cost includes some cartel rent as well as scarcity rent. Other analysts believe that world oil markets are not subject to substantial exercise of market power.

- If the United States has a motive but little ability to influence world oil price through its imports, then a large component of the import premium, the recoverable cartel rent (also called the monopsony premium), is near zero. The strength of U.S. buying power in world markets depends largely on the supply response of OPEC and other producers and the demand response of other consuming countries.

- Some of the costs attributed to noncompetitive supply (long-run inflation and balance of payments/exchange rate costs) are not well established theoretically or empirically. These components are excluded from the final premium estimates presented.

- The principal uncertainties regarding the disruption-related import costs are the likelihood of price shocks and the ability of the oil market and other input and product markets to anticipate and accommodate them smoothly with existing mechanisms.

- A long record of econometric analyses has repeatedly yielded evidence of a statistical relationship at the aggregate level between oil price disruptions and macroeconomic losses. Nonetheless, some recent, conflicting evidence suggests the need for a more careful disaggregated analysis. The contribution of macroeconomic adjustment losses to the oil import premium hinges on the marginal ability of import reductions to reduce shock size, either by influencing quantities of oil trade at risk or by reducing relative price rises.

- Quantitatively, the premium estimates are composed of three main components of roughly equal sizes: avoidable cartel rents; increased import payments during disruptions; and incremental macroeconomic adjustment losses.

- The marginal economic costs not counted in the market price fall within a total range of zero to $10.00 per barrel of imported oil but more likely within a range from zero to $4.60 per barrel of imported oil.

- Of the components omitted from the import premium estimates presented here, the unaccounted environmental costs associated with incremental oil imports stem mostly from oil transportation, and are quite small, probably $0.23 per barrel or less.

- The strategic insurance costs for oil-related military preparedness and for the Strategic Petroleum Reserve do not vary directly with the level of imports, so they cannot be added to the marginal economic costs to influence policy decisions on reducing imports at the margin. Additionally, the allocation of these costs per barrel of incremental imports is problematic. In particular, the clear attribution of military expenditures to particular missions has defied resolution to date, making a reliable assignment of some portion of those costs to imports impossible at present.

2.0 FRAMEWORK FOR ASSESSING OIL COSTS

2.1 The Interdependence of Consumption, Production, and Imports

The issues of possible market imperfections and social costs do not arise from imports alone, but also hinge on levels of consumption and production. This report focuses on oil imports rather than on consumption or production not because imports *per se* are presumed to have higher social costs than consumption, but because imports are of more immediate policy interest for the Domestic Natural Gas and Oil Initiative. While consumption may entail significant environmental costs, and it is an important determinant of our exposure to price shocks, such factors are outside the scope of this study.

A simple identity relates imports, consumption, and production of oil in the United States:[4]

U.S. oil imports = U.S. oil consumption - U.S. oil production.

Since imports are the difference between domestic consumption and production, the analysis of any oil policy would benefit from the evaluation of its full equilibrium effects on imports, consumption, and production, and their attendant economic, environmental, and energy security consequences. For example, the equilibrium effects of an oil import fee, an oil consumption tax, and a domestic oil supply incentive would differ. However, this study does not evaluate a specific policy but instead makes a first step by considering only a subset of the relevant issues. The focus here is exclusively on the effect of changing imports, without presuming particular changes in domestic supply or demand.

The oil import study uses a marginal partial approach: "marginal" because it is based on incremental changes in imports, and "partial" because it does not consider changes in production and consumption. This is a good means of isolating the costs and benefits directly attributable to oil imports to get a sense of the magnitudes involved, independent of policy choice. It avoids ascribing costs or benefits to imports which may not depend on imports *per se*, and is a precursor to policy analysis.

<u>The oil import premiums reported include only those external costs which arise from changing oil imports. They exclude costs which arise from changes in consumption or production, or which do not vary with the level of imports.</u>

2.2 Import Incremental Benefits are Largely Internalized

Private benefits are the benefits received by the buyer from using imported oil, which at the margin will equal the price paid. External benefits would be the benefits received by third parties not involved in the sale or purchase of oil imports. If one person's purchase of *imported* oil confers some benefits on someone not purchasing that oil, the marginal social benefit of imported oil would exceed its marginal private benefit, which is equal to its delivered import price. These potential

[4] This identity omits the minor effects of inventory changes. Also, the United States does export some petroleum. To account for that in this equation, imports could be changed to net imports.

benefits of oil imports are not included in the price, or are "external" to the price. In reality, however, the full marginal benefits of oil imports generally can be captured by private buyers, and there are no accepted significant external benefits of oil imports. Thus, at the margin, social benefits of oil imports are the private benefits.

The partial analysis conducted in the study omits consideration of induced changes in domestic production or consumption because such changes depend upon policies which are not specified. Holding constant oil consumption and domestic production also avoids counting external benefits of consumption or costs of production as external benefits of imports. Possible external benefits of imports which have been proposed by some include less domestic pollution, fewer tax distortions, and more efficient allocation of capital. These candidate benefit categories would arise from changes in domestic oil production, which our partial marginal analysis excludes. Nevertheless, after examination, it appears that at least two of these three possible external benefits of imports would be limited even if changes in production were considered. The proposed external benefits are revised here for completeness.

External Environmental Benefit

Imports may displace domestic production, thereby lessening the domestic pollution associated with production. However, there is very nearly a consensus among analysts that most environmental externalities associated with oil *production and transportation* have been internalized at the margin by additional insurance requirements, safety regulations, and private anticipations of law suits and fines in the event of spills and other damages. Consequently, the marginal external environmental *benefits* of oil imports can be expected to be small, as are the estimates of their marginal external environmental costs.

External Resource Allocation Benefit

To the extent that domestic oil production is subsidized through the tax code, the marginal resource cost of domestic oil production would be higher than the world price of oil. In this case, substituting imports for more costly subsidized domestic production would reduce external production costs, which might be interpreted as an external import benefit. Again, the present analysis, by holding constant domestic production, does not account for this effect, the magnitude of which is not known.

External Investment Benefit

Some have noted that reduced imports may require the use of scarce capital to increase domestic production, and thereby adversely influence the U.S. economy. For this capital saving to be an *external* benefit of imports the marginal resource cost of domestic oil production must exceed the market price, which is likely to occur only under the implicit tax subsidization argument discussed above.

Thus, even a more inclusive analysis of the full equilibrium effects of import changes on production and consumption may not reveal substantial external benefits of imports. Regardless, in the absence of such a full equilibrium analysis, it is proper to exclude marginal external benefits deriving from the reduction of domestic production, and no other marginal external benefits of imports have been identified by researchers.

2.3 The Issue of a Reference Point: Costs Relative to What?

When assessing the costs of oil, we must choose an appropriate reference point, that is, answer the question "costs relative to what?" Three reference points for comparison are: perfect market conditions; optimal levels of imports given market imperfections; and a marginal (small incremental) change in imports from a given level. At one extreme, the costs of oil imports can be measured relative to the competitive ideal. Such an ideal world would have competitive supply and demand, no unanticipated price shocks, and no unpriced environmental damages. In other words, the per-barrel costs of oil could be compared to the costs that would exist in the absence of market failures. Using the competitive ideal as a reference point would provide a general view of the magnitude of costs which we might wish to recover. This may be a useful guide for research and motivate the search for cost-effective solutions. It would offer no insight, however, on whether government can or should do anything about oil use or imports to avoid these costs. It would be a mistake to treat all costs beyond those of the competitive ideal as avoidable, since that implicitly assumes the existence of costless government actions which totally eliminate the market failures.

Secondly, the potential costs of oil may be defined in terms of the difference between the optimal (efficient) level and the current level of costs, recognizing that some government programs are already in place to respond to potential market failures. Since government action is not costless, the pragmatic issue is one of balancing the costs imposed by government intervention against the expected value of that intervention. The goal is to approach an efficient level of oil import costs, not to reduce those costs to zero. This optimal level is dependent on a host of conditions about the structure of the domestic and world oil markets, the vulnerability of the domestic and world oil markets to price shocks, and the relationship between oil markets and the macroeconomy. The efficient or optimal level of costs and imports may not be attainable with policies which are cost effective and pragmatically acceptable, but the concept has the merit of being a desirable reference point.

A third alternative reference point is the cost that would be caused by a marginal (small incremental) change in oil imports from the current, or alternatively, from the optimal, level. A small incremental reduction in imports may not be an efficient goal, but it has the virtue of being an achievable reference point. The marginal reduction in social costs of a change in import levels also reveals the amount we should be willing to pay (per barrel) to achieve that modest change. Hence, marginal cost is a useful guide for incremental policy.

2.4 Marginal Imports and Marginal Welfare

In examining the full costs of oil imports, one could estimate total costs, average costs, or marginal costs. Total costs (in dollars or dollars per year) must be measured relative to some reference value or alternative. Examples are relative to a perfectly competitive market [Greene and Leiby (1993)], or relative to optimal U.S. policy regarding import levels [e.g., Broadman and Hogan (1986), (1988), Huntington (1993)]. Average costs (estimated in dollars per barrel) require similar decisions about the reference point, as well as requiring that oil costs be carefully segregated into those attributable to consumption and those attributable to imports, so that the correct denominator can be used.

The principal method used in this report is the marginal analysis of U.S. welfare, employing the concepts of the economic welfare function and the oil import premium. The marginal costs of imported oil (in dollars per barrel) are the incremental costs associated with a unit change in oil imports.[5] Their estimation does not require that we know total costs, but only how total costs change with the level of oil imports. The usual analytical approach is to begin with a functional description of how U.S. economic net benefits depend on the level of oil imports. The term net benefits means the difference between benefits and costs. Here we begin with a representation of U.S. economic net benefit or welfare (relative to an arbitrary reference point), $W(q_{iu})$, which depends on the quantity of U.S. imports (q_{iu}).[6] Given the focus on imports, it is convenient to combine the domestic demand and supply curves into a net import demand curve. This corresponds to combining the private benefits of consumption and the private costs of domestic production into an import private net benefits function $B_i(q_{iu})$. The net economic welfare function includes import benefits $B_i(q_{iu})$, the direct costs of imports ($P_w q_{iu}$), and all other costs associated with externalities, shocks, and market failures ($C_e(q_{iu})$), which producers and consumers do not ordinarily consider.

$$W(q_{iu}) = B_i(q_{iu}) - P_w q_{iu} - C_e(q_{iu}) \tag{1}$$

The marginal welfare from a change in imports is then the marginal private benefit of imports less the marginal direct cost of imports less all the other marginal non-private costs identified:

$$\begin{aligned} W'_{social} \equiv \frac{\partial W(q_{iu})}{\partial q_{iu}} &= B'_i - \frac{\partial (P_w q_{iu})}{\partial q_{iu}} - \frac{\partial C_e(q_{iu})}{\partial q_{iu}} \\ &= B'_i - \left(P_w + q_{iu} P'_w\right) - \frac{\partial C_e(q_{iu})}{\partial q_{iu}} \end{aligned} \tag{2}$$

The *oil import premium* is defined as the difference between the marginal private net benefits of oil and the marginal social net benefits. Since it is generally believed that the social benefits of imports equal the private benefits, the import premium is the difference between marginal social costs and marginal private costs. In this case, the marginal social benefit is accurately measured by the price U.S. consumers would be willing to pay for oil, given the import quantity q_{iu}. This price, $P_{iu}(q_{iu})$, corresponds to the point on the import demand curve above quantity q_{iu}.

$$W'_{social} \equiv \left(P_{iu} - P_w\right) - \left(q_{iu} P'_w + \frac{\partial C_e(q_{iu})}{\partial q_{iu}}\right) \tag{3}$$

The marginal private cost of oil is the prevailing world oil price, P_w. So the marginal private net benefit of imports is $P_{iu}(q_{iu})$ - P_w. The oil import premium, π, being the difference between marginal private and marginal social value, is:

$$\begin{aligned} \pi(q_{iu}) &\equiv W'_{private} - W'_{social} \\ &= \left(P_{iu} - P_w\right) - W'_{social} \\ &= \left(q_{iu} P'_w + \frac{\partial C_e(q_{iu})}{\partial q_{iu}}\right) \end{aligned} \tag{4}$$

[5] Technically, marginal cost is the derivative of total cost, and is based on an infinitesimal change in oil use.

[6] Naturally, net benefit also depends on levels of oil production and consumption, but we are abstracting from these issues here.

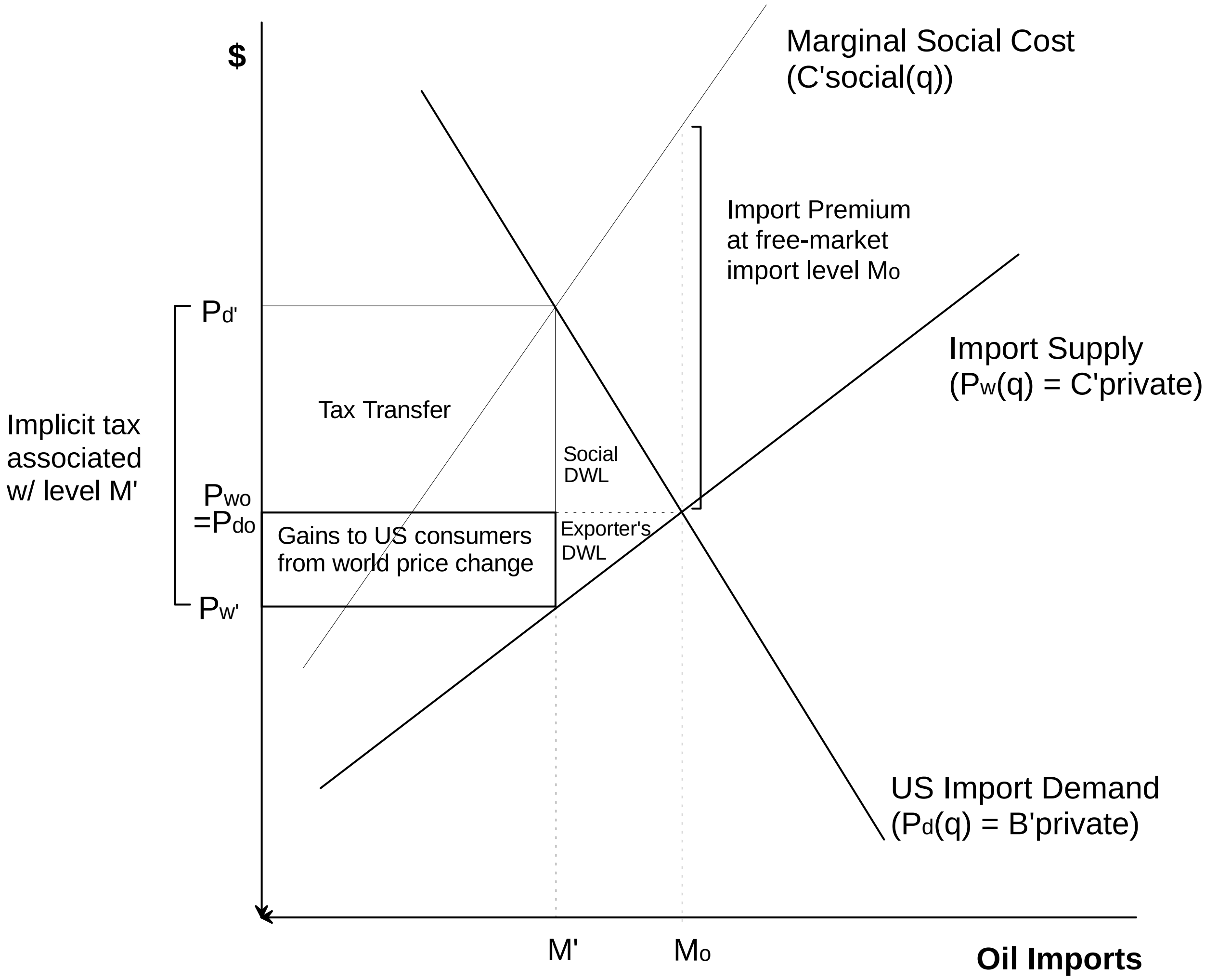
As will be discussed below, the first term of the premium corresponds to the monopsony or consumer buying power premium. The second includes all other marginal social losses such as the expected disruption losses.

2.5 The Base Import Premium and the Optimal Import Premium

The premium can be measured under base conditions (of essentially free-market policy) or under conditions where policy has reduced import demand. The former estimates the social gains from an incremental imports reduction from the current base level, while the latter estimates the social gains after imports have been reduced by a non-trivial quantity. Once the socially efficient level of imports is identified (that which maximizes social net benefit), the "optimal" import premium which applies at that level can be estimated. Note that neither the premium nor imports is necessarily reduced to zero at the optimal level. Many studies of oil import costs seek to estimate the optimal premium, since it serves as a guide for longer-run policy after a transition to lower imports has been made. As imports decline, the premium declines. Calculating the premium at the current level of imports rather than the (lower) optimal level would indicate too high an external cost.

A graphical representation may clarify the concepts of the base and optimal premia. Under free-market policy, import demand will adjust until the marginal private benefit equals world price, and the marginal private net benefit is zero. This is shown by the intersection of the import supply and demand curves in Figure 2.1, at imports level M_o. The base premium, $\pi(M_o)$, is shown as the difference between the private marginal cost (import supply) curve P_w and the social marginal cost curve C'_{social} above imports level M_o. The base or "free market" premium provides an estimate of the potential social gain from reducing imports by a small amount from their current level.

Figure 2.1: Deviation Between Marginal Social Cost and Marginal Private Cost of Imports Implies a Premium



If a policy is introduced to reduce imports below the free market level, M_o, to any other level, say *M*, then the marginal private benefits diverge from private costs. The foregone marginal consumption benefit exceeds the foregone *private* cost of imports. The difference between the new private benefit $P_{iu}(M)$ and the new world price $P_w(M)$ corresponds to an implicit tariff, $\tau(M)$, which would be needed (in the absence of other policy) to reduce imports to the level *M*. At the free market level M_o the implicit tariff is zero. While reducing imports to level *M* reduces private marginal net benefit by $\tau(M)$, the gap between social and private marginal costs is also declining. When imports are reduced to the level M', the gap between private benefits and private costs just equals the gap between social marginal costs and private marginal costs (the import premium), and no further reduction is beneficial. This is the optimal imports level, and the implicit tariff equals the optimal import premium. Note that this is also the imports level at which the social marginal cost intersects the private demand curve (Figure 2.1), so social: marginal costs equal private marginal benefits, which equal social marginal benefits:

$$\begin{aligned} C'_{social}(M^*) &= P_d(M^*) = B'_{social}(M^*) \\ P_d(M^*) - P_w(M^*) &\equiv \tau(M^*) = \Pi(M^*) \end{aligned} \tag{5}$$

The oil import premium is a useful concept for summarizing non-market costs, but should not be interpreted as an instrument of policy (NES Draft 1990:9). For example, Plummer et al. (1982) make the clear point that the two basic components of the import premium associated with non-competitive market costs and disruption costs each may motivate a different policy. The import premium indicates the marginal social value of a sustained reduction in imports, but does not indicate the most efficient policy for achieving that reduction. Similarly, the disruption component of the import premium should not be interpreted as the marginal value of stockpiling against a disruption, in order to offset imports during a disruption. This value could be estimated separately, as in the Plummer et al. (1982) "stockpiling premium," or numerous other stockpiling studies [e.g., Teisberg (1981), Hogan (1982), Leiby and Lee (1988), DOE/Interagency Study (1990)].

2.6 Bases for Expert Disagreement: Views of the Costs of Oil Market Instability to the U.S. Economy and Oil Exporter Market Power

2.6.1 Divergent Views

The current disagreement about potential oil costs is explained in part by different views among analysts regarding the potential exercise of oil exporter market power and the possibility of market failure costs to the U.S. economy following oil price shocks. To highlight this, a simple 2-by-2 diagram is useful.

Figure 2.2 presents a simple two-dimensional matrix that represents alternative "Views of the Effects on the U.S. Economy" and "Views of Oil Exporter Market Power." The two polar views of the effects on the U.S. Economy are "Minimal Market Failure from Oil Market Instability" and "Substantial Market Failure from Market Instability." The minimal market failure view describes a world where oil price shocks are largely anticipated and hedged against that possibility, and the U.S. economy is one that smoothly and efficiently adjusts to the sudden increase in oil prices. Substantial market failure would describe a world where oil price shocks were largely unanticipated and little hedging is done in anticipation of oil price shocks, and where the economy underperforms in trying to adjust to the oil price shocks.

Price shocks can be of two general types: (1) temporary price shocks that may last for a few months, but not more than a few years; and (2) sudden, large, and long-run price increases that reflect a sudden movement to a new price plateau and a fundamental change in the world oil market. For the most part, analysts have focused on price shocks of the first type. This is an important distinction because the opportunities for policy action in the two cases will differ. A temporary price shock could be eliminated by a sufficient drawdown from public stocks, which would avoid all the associated costs. However, in the case of a sudden movement to a new price plateau, the long-term price increase is not preventable through buffer stocks, and the mitigative effects of other policies need to be explored. In either case, the short-run adjustment costs associated with the movement to that new price level are potential costs of concern.

The two polar views of exporter oil market power can vary from a minimal exercise of oil exporter market power to substantial exercise of market power, with many alternative market structures between the two. With a minimal exercise of exporter market power, the world is one where OPEC has little capability to control oil prices, and oil prices are close to levels that would occur in competitive markets. At the other end of the range, a world with substantial exporter market power would be one where OPEC sets the world oil price to its preferred level.

Figure 2.2: Potential Costs of Oil Imports and Consumption

View of Oil Exporter Market Power

Views of Effects on U.S. Economy	Minimal Exercise of Oil Exporter Market Power	Substantial Exercise of Oil Exporter Market Power
Minimal U.S. Economy Market Failure From Oil Market Instability	**Potential Events** • Shipping Spills • Storage Leaks • Evaporation/Combustion **Potential Costs** • External Health and Environmental Cost • Routine Price Volatility Costs	**Potential Events** • Exercise of Monopoly and/or Failure to Exercise Monopsony Power by U.S. **Potential Costs** • Excess Wealth Transfers to Oil Exporting Countries • Higher Oil Costs, Loss of Potential GNP • Environmental Costs Reduced Due to Lower Consumption
Substantial U.S. Economy Market Failure From Oil Market Instability	**Potential Events** Accidential Interruption of Production or Transportion • War • Terrorism • Natural Disasters • Unrest (Labor Strikes, Change in Regime) **Potential Costs** • Surplus (Potential GNP) Losses • Excess Wealth Transfer to Oil Exporters • Macroeconomic Adjustment Costs • Military Security Costs • Costs of Policy/Contingency Measures (e.g., SPR) Lesser/Speculative Macro Costs • Aggregate Demand Shortfall (Short-run Leakages) • Inflationary Effects • Capital Investment Effects	**Potential Events** • Opportunistic Exercise of Monopoly Power During a Disruption • Significant Changes in Market Structure Resulting in Oil Price Spikes and/or Changes in the Probabilities of Price Spikes • Significant Changes in Political Objectives of Producing Countries • Failure of Importers to Exercise Deterrence **Potential Costs** • Costs of the Same Types, but Potentially More Severe if Monopoly Power is Exercised • Higher Likelihood of Disruption Military/Security & Political Costs: • Preparedness costs for potential conflicts over supplies • Cost of assuring availability of oil to military during conflict

Each world view is associated with particular events and categories of potential costs (see Figure 2.2). The upper-left region is representative of an essentially competitive oil market with the U.S. economy suffering only minimal market failure costs in the event of a severe oil price shock, but with the possibility of health and environmental externalities. In the upper-right region, the economy still is characterized by minimal market failure, while oil exporters are assumed to wield substantial market power and health and environmental externalities remain. The lower-left region is representative of a competitive oil market and a U.S. economy that is characterized by substantial market failure costs in response to price shock plus health and environmental externalities. The bottom-right region contains the most severe cost conditions: the oil market is characterized by oil exporters having substantial market power, the economy suffers from market failure costs after oil price shocks, and health and environmental externalities remain. Note that potential costs are cumulated as we move to the right and down. Only the added costs of moving from one market view to another are highlighted in the figure. The four quadrants constitute four different world views, and are discussed in turn below..

2.6.2 Minimal Oil Exporter Market Power/Minimal U.S. Economy Market Failure

Some contend that today's world oil market shows little evidence of supplier market power or vulnerability to price shocks. To defend that position, they argue that although there may be severe oil price shocks in the future, these shocks are anticipated and hedged, and the U.S. economy will smoothly and efficiently adjust to an oil price shock. They point to the factors mitigating price shocks: the increased use of spot and futures markets; pricing methods such as netback pricing (when used, ties the price of crude to the market price of products); the existence of the U.S. Strategic Petroleum Reserve (SPR); and greater flexibility of domestic suppliers and demanders to adjust to price fluctuations. For example, a study by Tussing and Van Vactor (1988) points to the widespread introduction of facilities to accommodate fuel switching and to allow greater domestic supply, especially in the areas of transportation and refining (where there is now greater ability to refine heavy crude oils and residual oil into gasoline and other light distillates).

While acknowledging that members of OPEC are capable of influencing the market price of oil, advocates of the no substantial exporter market power view argue that OPEC has not exercised its market power historically and that other factors explain members' behavior [e.g., Bohi and Toman (1993), MacAvoy (1982) and Teece (1982)]. They point to OPEC's reduced market share and explain past oil price increases as the results of individual political events and demand-side responses, not the exercise of monopoly power. They argue further that although the United States may possess monopsony power in the world oil market, it does not follow necessarily that a potential monopsony position should be exploited. Some analysts argue that U.S. monopsony power is, in fact, very limited, and any declines in U.S. demands are apt to be offset partially by increases in other countries' demands [e.g., Walls (1990)]. The main argument against the use of monopsony power, however, is the potential retaliation of major exporting countries [Nesbitt and Choi (1988)]. If OPEC is not already earning monopoly profits the exercise of monopsony power could bring greater cohesion to the would-be cartel. Increases in world oil prices could result, which would leave the United States worse off.

Therefore, in this world view, costs associated with market failures in the U.S. economy from oil price shocks and oil exporter market power are limited and thus not important for policy. Potential costs of oil production, imports, and consumption are reduced to those associated with environmental and health externalities. (Environmental and health externalities are discussed in detail in another section of this report.)

2.6.3 Minimal Exporter Market Power/Substantial Market Failure in U.S. Economy

In this view of the world, oil exporters have little market power, but the U.S. economy suffers from substantial market failure costs from oil price shocks. The possibility of price shocks raises the prospect of incomplete markets and therefore external costs if producers and consumers are unable to anticipate and adequately "insure" themselves against such market contingencies. These costs result from a broad set of possible market imperfections, including incomplete insurance or hedging opportunities, excessive market uncertainties, rigidities of domestic markets for oil and other goods and services dependent on oil, and/or institutional/regulatory constraints that may cause domestic producers and consumers of oil to underinvest in capital equipment and oil stockpiles to respond to oil price fluctuations. Substantial exporter market power, however, is not a serious concern to proponents of this world view.

2.6.4 Substantial Oil Exporter Market Power/Minimal Market Failure in U.S. Economy

In this world view, oil exporters have substantial market power, but there are only minimal market failures in the U.S. economy when there are oil price shocks. Thus, this situation suggests two potential market failures -- health and environmental externalities and potential monopoly/monopsony power. However, if suppliers possess market power, it is an open question what can be done to prevent its exercise. If nothing can be done to counter or prevent the exercise of market power, the long-term cost associated with a higher world oil price may be large, but may not be avoidable. While the avoidability of particular cost categories is not really the issue we seek to address, it is true that the cost estimates of substantial oil exporter market powers provided in the literature depend critically on the assumed ability of changing U.S. import levels to influence OPEC supply, non-U.S. oil demand, and thereby price. These matters are discussed further in Chapter 3.

2.6.5 Substantial Oil Exporter Market Power/Substantial Market Failure in U.S. Economy

In this view of the world, there is substantial exercise of market power on the supply and demand sides and oil market price shocks trigger substantial market failure costs in the U.S. economy. The potential costs of oil imports and consumption are of the same types as identified in the previous discussions of alternative world views, although the magnitudes of the costs may be more severe when markets characterized by oil exporter market power exist in combination with a U.S. economy that suffers substantial market failure costs during oil price shocks. For example, monopolistic producers may take advantage of temporary disruptions in world supplies (e.g., wars, terrorism, natural disasters) to solidify their market power and increase world oil prices. In other words, a supply disruption may allow a "clumsy cartel" to become something closer to a profit maximizing oligopoly. Major producers may also be encouraged to fabricate disruptions. Therefore, the probability of disruption may be larger.

This view of the world also opens the possibility that price shocks could result from a significant shift in world oil market structure. For example, a clear change in the leadership of OPEC, owing to political factors within or between member countries, could result in altered pricing objectives and short-run production shifts. Of equal importance, an acknowledged change in leadership could lead to significant changes in future expectations by oil consumers, with resulting changes in private stock levels and long-term contract prices. The combination of these changes could result in a price shock, even without a disruption in the production of crude oil.

Alternatively, the existence of market power on the demand side may allow oil importers to take actions to deter disruptions. For example, the existence of public oil stocks or the threat of monopsony power may deter producers from fabricating an oil disruption or taking advantage of a supply disruption to increase world oil prices.

2.7 Understanding Different Estimates of Import Costs, and Organizing the Potential Cost Categories

Figure 2.2 highlights the two principal determinants of imported oil costs: the degree to which oil exporters exercise market power and the degree to which market failure costs are imposed on the U.S. economy after an oil price shock. These issues are not well resolved, and the four categorical views described here are variants in the range of expert opinion. It is ranges of opinion, such as those presented here, that explains why estimates of the social costs of imports found in the literature diverge so widely. The simplified 2-by-2 representation of Figure 2.2 also emphasizes that potential import costs fall into two distinct categories: those which would follow from the sustained exercise of oil exporter market power, and those attributable to the market failures in the U.S. economy that lead to potential costs following, and during, an oil price shock. The next two chapters address each of these categories in turn considering whether marginal external costs of imports exist and how they might be estimated. For each of the potential costs listed in Figure 2.2, the actual magnitude and policy relevance of marginal costs borne will depend upon other factors. Principal among these are whether the U.S. can and should mitigate supplier market power by reducing its imports, and whether the possible disruptions entail non-trivial external costs which vary with the level of imports.

3.0 NONCOMPETITIVE MARKET COSTS: EXISTENCE AND MEASUREMENT

The exercise of market power by OPEC, even if imperfect and clumsy, may generate some economic losses to the United States as a net oil importer. The first section of this chapter describes the disagreement about the degree to which OPEC can or does exercise market power. The second section discusses the conditions under which the United States might be able to reduce possible noncompetitive market losses through policy action and whether other considerations might restrain such actions. The third section reviews various costs which monopolistic or oligopolistic behavior of oil exporters may impose on an importer, both directly and indirectly. The fourth section discusses how the exercise of monopsony, or buyer, power over oil prices might be able to counteract the price-raising effects of monopoly power. The final section of the chapter reviews numerical estimates of the monopsony premium, which is the amount of the monopoly effect on price which the exercise of monopsony power could retrieve for a buyer.

3.1 Variation of Opinion on OPEC Monopoly/Cartel

There is significant disagreement about the degree to which OPEC or any set of oil producers can, or does, manipulate oil prices. Although the capacity of OPEC or a subset of OPEC to exercise market power is acknowledged, it is generally agreed that OPEC's power has not been exercised fully. There are several views of how OPEC market decisions are made. For example, Adelman (1980) has viewed OPEC as a "clumsy cartel" that has exercised its power only partially. Others, such as Teece (1982) argue that OPEC decisions are based on the ability of exporting countries to absorb oil revenues rather than the exercise of market power. Once petroleum prices rise beyond a point where revenues cannot be absorbed comfortably, exporters reduce production, so the argument goes. MacAvoy (1982) also takes issue with the conventional wisdom that oil prices reflect significant monopoly power. According to his study, the significant price increases of the 1970s resulted from political events and demand-side responses, not concerted OPEC actions.

Several empirical studies have rejected the hypothesis that OPEC countries behave competitively and have tended to support the˝notion that OPEC functions as a cartel [e.g., Dahl and Yücel, (1991); Jones (1990); Griffin (1985)]. The very existence of price-setting and production quotas is proof that OPEC is attempting to exercise market power. Others˝analysts, however, have cited evidence that individual OPEC members have undermined official˝OPEC˝price structures and˝violated OPEC production quotas as proof that OPEC is not an effective cartel˝[e.g., Okogu, (1990)]. But the˝issue is not whether OPEC is a perfect cartel, rather the degree to which it exerts market power on world prices.

Following the Persian Gulf War of 1991, some have surmised that OPEC may˝be finished. This view holds that there are new political conditions in which the interests˝of the key Persian Gulf producers, Saudi Arabia and Kuwait, are permanently aligned with those of˝the West, and that the interests of the major producers in withholding production is undermined˝in any event by˝debt burdens and development demands, which would˝tend to undermine Teece's˝explanation of OPEC behavior. On the other hand, the entire history of the˝world˝oil trade has been one of˝attempts to monopolize [e.g., see Yergin (1991)].˝ Furthermore, the trends are toward˝ever-increasing˝OPEC market share, and the rewards for reestablishing the oil cartel are great:

> "The rewards of monopolizing the world oil industry have been so huge that . . . [if] the cartel collapses it will reappear, perhaps with a partly different membership. Whenever they settle their differences they can cut production, and raise the price." (Adelman, 1990:12)

An imperfect measure of the degree of non-competitive supply behavior could be gained by comparing prevailing prices with estimates of the competitive oil price. Yergin [1991] argues that it is not clear that the world oil market has ever been truly competitive, in the sense of being free from monopolistic influence by states or corporations. If the world oil market was approximately competitive before members of the OPEC cartel disrupted world oil prices in 1973, then the 1972 price, in real dollars, should be some indication of what the price would be today in a competitive market. In 1972, the refiner acquisition cost of imported oil to U.S. refiners was $10.30/BBL in 1993 dollars [U.S. DOE/EIA, (1994)]; the corresponding price was $16.14/BBL in 1993.[7] A second approach is to review predictions by modelers and analysts of competitive market world oil prices. These generally range from $5-$10/BBL, 1990$ [Energy Modeling Forum 1992:103, Greene and Leiby (1993)]. A third approach is to examine data on the costs of developing oil reserves, and make adjustments for any depletion or scarcity rent. Estimated finding and lifting costs for the OPEC countries fall in the range of $0.10 to $3.00 per barrel, with the Persian Gulf producers generally below $1.00/BBL [Adelman and Shahi (1989); Dahl and Yücel˝(1991)].

Some assert˝that any scarcity or depletion rent component of the world oil˝price is small,˝since, for practical purposes, oil is not an exhaustible resource (Adelman 1990:9).˝ Oil resources are sufficiently large that the market is concerned almost˝entirely with the marginal˝cost of developing additional reserves and almost not at˝all with the eventual depletion of those reserves. ˝Despite several noteworthy efforts to modify and extend the Hotelling (1931) depletable˝resource model to capture the reality of the world oil market [e.g., Gilbert (1978); Alsmiller, et al., (1985); Marshalla and Nesbitt, (1986); Stiglitz, (1976)] its explanatory power˝remains limited˝[Watkins, (1992)]. In fact, Mabro (1992) suggests that the Hotelling model˝appears to˝predict oil price behavior˝only *during* disruptions, and that a cartel model˝seems to explain oil˝prices best during normal, undisrupted periods.

In 1975, world proven oil reserves stood at just over˝700 billion barrels.˝ In the next fifteen˝years, the economies of the world produced and consumed 360 billion barrels of oil. Yet at the˝end of that period, world proven reserves stood at 990 billion barrels, a net˝increase of reserves of˝290 billion barrels. The fear of exhaustion followed by continual replenishment of˝reserves is not˝a new phenomenon; this is the way it has been since the Standard˝Oil Trust in the early 1880s (Yergin 1991:51-52).

Simply running out of oil is not the problem, even if˝the Hotelling theory applies, due to the size of the resource base:

> "The geophysical limits may bite one day, but this day of reckoning is so far ahead as to have, on any conceivable assumption about discount rates, no impact on price." (Mabro 1992:3)

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[7] The oil price fluctuates routinely. As of this writing (5/12/95) it is $19.75/BBL for Arabian Light.

This point is crucial because if it is not the inexorable economics of exhausting the world's oil resources that causes oil prices to exceed marginal extraction costs, then it must be something else, and the widely accepted explanation is the exercise of monopoly power (Toman 1993:1178).

3.2 Taking Action on Monopoly/Oligopoly Power in International Trade

The exercise of monopoly or oligopoly power transfers surplus from consumers to producers and leads to losses of output. When both the monopolistic seller's and the buyers' interests are considered, that is, when the monopoly is a domestic firm, the welfare loss from monopoly is only the deadweight loss. The transfer is not a loss, but rather a redistribution. When the monopolistic seller and the buyers are residents of different accounting units, such as nations, the transfer excess of wealth from consumers to seller can be accounted a cost to the buying nation, although the entire world's welfare will experience mostly redistribution rather than a major amount of lost output.[8] Consequently, there is a potential reason for concern domestically about the excess wealth transfers of monopoly (or oligopoly) rent when international trade is involved.

Foreign monopoly power—in this case, OPEC market power—can be offset in international trade only if an importing country accounts for a large enough share of the world market to be able to affect the world price of the product by its buying behavior. A country having such buyer power is said to have monopsony power. By reducing its purchases of the monopolized good, such a country can reduce the world price somewhat. Tariffs, quotas, domestic supply incentives, and consumption disincentives can be used to accomplish such a reduction in imports. Monopsony power also is greater when the price responsiveness of OPEC and other producing and consuming countries is limited. The exercise of monopsony power in an international market characterized by competitive supply conditions would not be desirable, but the use of monopsony power to offset seller market power may be an desirable intervention to correct a pre-existing distortion.

Even if OPEC does behave as an effective cartel, and if the United States could exert countervailing monopsony power to mitigate the excess wealth transfer from the United States to OPEC oil suppliers, there may yet be reasons for the United States not to exercise that power. While such policies might effectively retain monopoly rents for the United States, the political ramifications of such actions might destabilize an important ally within OPEC such as Saudi Arabia. The consequences of such destabilization could be far more costly to United States interests than a continued excess wealth transfer. Some analysts believe that exercising monopsony power may also provoke retaliation by less than perfectly colluding suppliers that more than offsets the rent recapture. Such a scenario entails at least some cartel discipline while characterizing the cartel as too loose to be effective in raising prices in the first place.

3.3 Costs of Noncompetitive Supply

The long-run exercise of monopoly power leads to world and domestic oil prices that are higher than competitive levels. The resulting sustained oil price increases impose long-term costs. A gradual price increase under conditions of full employment will impose long-run consumer surplus losses, higher U.S. production cost, and an excess transfer of wealth to foreign producers in the form of monopoly rent. These losses and transfers will be determined by the domestic long-run curves, not by the capital inflexibilities incorporated in a short-run analysis. When the market has fully adjusted

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8 As mentioned previously, "excess wealth transfer" refers to transfers beyond the actual resource costs of the commodity, or what would obtain under competitive conditions.

to a higher, cartelized oil price (with the economy moving to a more constricted production frontier than is achievable with competitive oil prices), a larger fraction of U.S. production goes to overseas claimants as oil import payments.

3.3.1 Direct Costs of Monopoly Power

Sustained Monopoly Rent Costs

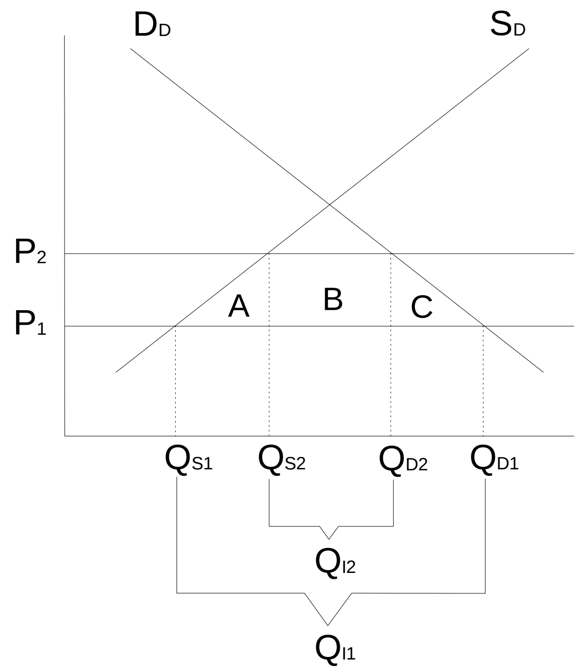
The largest component of the cost of oil at non-competitive prices is the excess payments from oil consumers to oil producers. This excess payment beyond what would be paid at competitive prices is called monopoly "rent". The situation of an oil importer facing a noncompetitive supplier is depicted graphically in Figure 3.1. At a competitive price P_1, the United States would produce Q_{S1}, consume Q_{D1}, and import Q_{D1}-Q_{S1}. At the higher monopoly price, P_2, the United States produces a greater quantity, Q_{S2}, consumes a smaller amount, Q_{D2}, and imports a smaller amount, Q_{D2}-Q_{S2}. The United States must pay much more for the oil it imports, indicated by the area B. The area B is an excess payment of U.S. wealth to foreign producers. Some of this payment goes to pay for the cost of increased world oil production but most of it is monopoly rent. Rents within a society are traditionally not considered economic costs because they are a transfer, not a loss of real resources. While payments abroad of true resource costs are a necessary, and indeed desirable, aspect of international trade, here we are concerned with excess payments -- beyond resource costs -- to non-competitive suppliers.

Sustained Loss of Economic Output (GDP)

Another cost of higher-priced oil is a reduction in the economy's ability to produce [e.g., Pindyck (1980), Pakravan 1984:15-19]. Higher monopoly oil pricing increases the economic scarcity of oil. The capability of our economy to produce, and also that of the entire world, is reduced.[9] This effect is long-run in nature and does not decrease over time as the economy adjusts to the higher prices. To emphasize the long-run nature of this phenomenon we refer to the loss in "potential GNP." Potential GNP is the technical term for the maximum sustainable or high employment GNP (Samuelson and Nordhaus 1985:79). The loss of GNP from an increase in oil prices depends on the importance of oil to the economy, and the ability to substitute other energy, capital, and labor for oil. Absent any substitution of either capital or labor for energy, the long-run potential GNP loss elasticity with respect to energy price is $-\sigma_E$, the cost share of energy [Bohi (1989), Ch. 3]. As Bohi (1989) points out, if both capital and labor are gross substitutes for energy the long-run elasticity of potential GNP with respect to the price of energy will certainly be smaller (in absolute value) than σ_E. We refer to this as the long-run effect of energy prices because it excludes macroeconomic adjustment losses which, in the short-run, will prevent the economy from reaching its long-run, full employment, potential output level. Any short-run adjustment losses are categorized here as disruption losses.

[9] Put another way, the world's production possibilities frontier has shifted inward (i.e., the world has become poorer). See, e.g., Pindyck (1980) for a discussion of the scarcity effect.

Figure 3.1: Direct Costs of a Monopolistic or Disruption Price Rise



Since the long-run potential GNP loss corresponds to the full factor-employment outcome, this loss may be estimated either with a simple macroeconomic model, <u>or</u> by the social surplus loss triangles in the traditional microeconomic representation of the oil market, but <u>not</u> both. Each method has been used in the past. As discussed elsewhere [Horwich and Weimer (1984), Broadman and Hogan (1986), Leiby and Lee (1988), Greene and Leiby (1993)] the domestic producer cost and consumer surplus loss triangles (areas A and C in Figure 3.1) measures the full-employment GNP change associated with a price increase. Any such potential output loss is in addition to the increased payment of rents for imported oil (area B in Figure 3.1). In the oil sector, oil consumption falls from Q_{D1} to Q_{D2}, with a concomitant loss of consumers' surplus (the triangle C) as a result of the higher price. The consumers' surplus loss for a factor of production like oil equals the lost GNP that would have been produced from the oil. To expand U.S. oil production to Q_{S2}, capital and labor must be spent; this is represented by the triangle labeled A.[10] This extra production cost is a deadweight loss to the U.S., and to the world economy. Area B, due to increased payments for oil imports, is not a reduction in potential GNP, but an increased claim by foreign interests on U.S. output/GNP [Huntington and Eschbach (1987)].[11]

In estimating the total or average output losses due to costs of imports, the area of the social surplus triangle between the prevailing price and some reference price (basis of comparison) would be calculated and attributed to imports. The problematic step is establishing a reference price or import level for which the attribution of the surplus losses to imports is appropriate.

Estimating the marginal effects of imports on output/social surplus is clearer. To estimate the oil import premium, the marginal gain in GDP/social surplus attributable to an increase in imports must be counted and weighed against any marginal increases in external costs. The change in social surplus is equal to the incremental area under the (inverse) import demand curve $P_{iu}(q)$:

[10] If private US supply cost is less than full social cost because of favorable tax treatment, higher domestic oil prices will increase the deadweight loss.

[11] There is frequently an argument about whether the money represented by **B** will or will not return to the U.S. economy in the form of increased demand for U.S. exports. From the perspective of the welfare of U.S. citizens the point is, who gets the output of the U.S. economy? Leiby and Lee (1988) have termed this "Domestic Absorption" versus "Foreign Absorption" of U.S. output. Domestic absorption (how much of our GNP we get to keep) is a better measure of U.S. welfare than gross output (how much we produce).

$$S(q_{su}) = \int_{q_{du0}}^{q_{du}} P_{du}(q)\,dq - \int_{q_{su0}}^{q_{su}} P_{su}(q)\,dq = \int_{q_{iu0}}^{q_{iu}} P_{iu}(q)\,dq$$
$$\frac{dGDP_{pot}}{dq_{iu}} = \frac{dSS(q_{iu})}{dq_{iu}} = P_{iu}(q_{iu}) \qquad (6)$$

The marginal reduction in output is just the import demand price P_{iu}, which equals the marginal net benefits of imports. This term is counted in the marginal welfare expression developed above (Equation 5).

3.3.2 Indirect Costs of Monopoly Power

Several analysts have identified two principal indirect social costs from the exercise of cartel power in the world oil market: a long-run deteriorating effect on the balance of payments (or the value of the dollar) and a long-run, cost-push inflationary effect. Subsequent literature on the balance-of-payments effect has shown greater complexity to the issue and correspondingly less clear directions of effect, and the inflationary cost has both weak theoretical foundations and a very small empirical magnitude at any rate. However, both possible social cost categories have had a stubborn half-life in the oil literature, and we discuss the mechanisms originally envisaged for both simply to air the full range of views on all possible costs. In our "most recommended" social cost calculations, presented in Section 5.3, we exclude both of these cost categories.

Long-Run Balance of Payments Costs (terms of trade)

Nordhaus (1980) first raised the prospect that a substantial trade imbalance due to oil imports could generate indirect macroeconomic costs. If the United States is importing a large amount of oil, the long-run balance of payments constraint necessitates an exchange rate adjustment which worsens the terms of trade for the United States. U.S. goods become cheaper to foreigners, and foreign goods become more expensive to U.S. consumers. In this case not only would there be a substantial excess wealth transfer overseas for oil, but other imported goods would become dearer.[12] The mechanism by which this occurs has been well described elsewhere [Broadman (1986), Hogan and Broadman (1988), Huntington and Eschbach (1987)]. The strength of this effect depends on the fraction of oil payments recycled to the United States, and on the degree to which the U.S. trading partners are also subject to oil-induced currency readjustments. If there is immediate and full recycling, then there is no balance of payments "externality," but the excess wealth transfer or foreign claim on U.S. GNP still occurs.

There is some confusion as to whether this effect is a cost in *addition* to the transfer of wealth, or simply another manifestation of it. Huntington (1993) argues that regardless, the incremental effect of imports on the terms of trade is small. He notes that the imbalance between savings and investment is far more important over the long-run than oil trade in affecting trade balance and exchange rates. Many other analysts generally assert that the indirect balance of payments effect is small, if it exists at all, and omit it from their premium estimates.

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[12] As mentioned previously, "excess wealth transfer" refers to transfers beyond the actual resource costs of the commodity, or what would obtain under competitive conditions.

Nordhaus made some simple and admittedly "treacherous" calculations of the balance of payment cost, estimating that the indirect cost may be half of the real resource costs (world price) of oil ($15 in 1979, using 1993 dollars). Hogan (1981) suggests that this figure is an upper bound, since many U.S. trading partners are significant oil importers. The most recent effort to explicitly estimate the balance of payments costs was by Broadman and Hogan (1986). The method extends Hogan (1981), determining the exchange rate variation necessary to restore the trade balance after an incremental increase in imports occurs and an assumed fraction R of any increase in oil import payments is recycled. The balance of payments marginal cost (premium) is the product of the elasticity of import price with respect to exchange rate (η_{pe}) and the elasticity of exchange rate with respect to import quantity (η_{eq}):

$$\pi_{BOP} = P_i \eta_{pe} \eta_{eq} \tag{7}$$

The first elasticity reflects OPEC's desire to adjust the dollar-denominated oil price if the U.S. exchange rate worsens. Broadman and Hogan assume an elasticity of -1.0, assuming producers wish to maintain the purchasing power of their oil. The second elasticity translates the change in import quantity into the necessary exchange rate variation to balance payments. It is sensitive to the recycle rate, and varies directly with import levels (Broadman and Hogan 1986:A-12). The elasticity of exchange rate with respect to import quantity is low when recycling rate "R" is near 1 or the elasticities of import and export demand are high. This is consistent with the expectation that the balance of payments cost is small when trade adjustment is fast and recycling is complete. Broadman and Hogan's (1986) estimate of balance of payments premium at the optimal imports level was on the order of $1/BBL (1993$). A simple adjustment of this cost would multiply by the ratio of the 1993 oil price ($17) to the 1985 price used by Broadman and Hogan ($35, 1993$). Thus, all else equal, the Broadman and Hogan approach would estimate the current balance of payments premium to be about $0.50/BBL.

The balance of payment cost component is less well established empirically or theoretically than other costs (Toman 1993:1188-9). Those who argue against including long-run balance of payments costs note that the net effect on trade patterns of an oil price increase is ambiguous. The initial trade imbalance felt by an oil importer will be experienced by all importing countries, not just the United States. The net effect on international competitiveness and trade depends on each country's ability to adjust to higher oil prices [Marion and Svensson (1986)]. The principal oil exporters spend or invest most of their oil revenues in the oil-importing, industrialized countries, and the net effect on the demand for any particular currency will depend on OPEC's relative spending patterns among those countries [Krugman (1983)]. Additionally, the modeling of this phenomenon to date has not made the important distinction between tradable and nontradable goods in the industrialized countries; the reduction in domestic spending will be allocated among those categories of goods as a consequence of increased oil payments can have a significant effect on the exchange rate. Finally, since oil prices denominated in U.S. dollars, a change in price will alter the demand for U.S. currency by all importers.

Long-Run Inflationary Costs

The potential for a long-run rising oil price trend to induce inflationary costs was also raised as significant issue by Nordhaus (1980). It is not inflation, but the measures to limit inflation, which are thought to impose significant output losses. Hence, one important assumption is the extent to which inflation is accommodated versus eliminated through fiscal and monetary restraint. The costs of controlling inflation stem from market rigidities and imperfect foresight. With perfect flexibility and perfect anticipation, this would not be a problem.

The concern is for inflation following from a long-run trend of increasing prices.[13] Hence, it is an externality associated with the time-rate of price change (dP/dt), and therefore the time rate of demand change (dQ_i/dt). One complication is the volatile sequence of actual price movements, which disguises an uncertain trend. Hogan (1981) noted that the impact of an oil price change on the aggregate price level will be proportional to the value-share of the consumption of oil and related products in GNP (Broadman and Hogan include natural gas consumption). Nordhaus formed quick estimates of the costs of inflation assuming no accommodation, where inflation is generated from the (unexercised) monopsony effect and from terms of trade deterioration. Nordhaus's estimates of $2 to $10/BBL assume that reducing inflation by 1 percent costs 4 percent of GNP for one year.

Following Nordhaus and Samuelson (1985:437-9), and Hogan (1981), Broadman and Hogan (1986, 1988) provided an estimate of the inflationary marginal cost (premium) of imports. The estimation method combines two rules of thumb: a Phillips curve relating inertial inflation to excess unemployment, and Okun's law relating changes in unemployment to changes in output. The Phillips curve suggests that the economy must suffer 2 percentage points of increased unemployment for a year to eliminate 1 percent from inertial inflation [Nordhaus and Samuelson (1985)]. Okun's law implies a 2 percent loss in GNP for each percentage point of excess unemployment, at the margin [Nordhaus & Samuelson (1985)]. This implies a roughly 4:1 link between output loss and the reduction of inertial inflation. The approximation used calculates the long-run impact of inertial inflation assuming full anticipation and accommodation. It then applies judgement to determine the fraction of oil inflation removed through macroeconomic policy actions.

Hogan and Broadman estimate a long-run inflationary optimal premium of $1-$2/BBL (1993$), depending on the magnitude of other premium components. The inflationary premium of Broadman and Hogan is proportional to the fraction of inflation not accommodated, and roughly proportional to rate of oil price inflation and the share of GDP spent on oil and related products. The 1994 DOE International Energy Outlook projects real oil prices to rise at 3.4 percent, compared to Hogan and Broadman's 3 percent. The Hogan and Broadman assumption that 30 percent of inflation would be unaccommodated (eliminated) seems conservative, given current desires to limit inflation. In 1985, the share of GDP spent on oil was 3.6 percent, currently the share is about 1.7 percent, projected to rise to 2.5 percent by 2010. The expenditure share of oil substitutes has grown relative to the oil share, although it is not known which substitutes are included in the Broadman-Hogan calculation. Overall, an updated 1994 estimate of the inflationary premium would be roughly half of its 1985 value ($0.60-$1.00/BBL) and growing as the oil share expands.[14]

Toman (1993:1189) and others find the long-run inflationary cost component to be suspect. The long-run inflationary cost, which some analysts attributed to larger oil imports, relies on an indirect, cost-push mechanism. If increased oil imports caused a higher trend rate of growth in real oil prices,

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[13] The inflationary effects of price shocks or one-time price shifts are conjectural and possibly negligible.

[14] Note that the Broadman-Hogan premium estimates are at optimal import levels, which will also change as cost parameters change. Hence, this effort to update their estimates is very rough indeed.

and if that real price trend were somehow turned into an effective cost-push inflationary mechanism, a higher long-term rate of growth of the price level could ensue. Cost-push theories for inflation have declined in popularity since the early 1970s, with a wide acceptance of the concept that inflation is primarily a monetary phenomenon influenced by the relative rates of expansion of the money supply and real production. Furthermore, the share of oil in the price-level deflator is small, leaving only a small component for oil price increases to contribute to general price-level growth. Of course, those who estimate an inflation cost component would hold that matters of numerical magnitude are better resolved by direct calculation than by a presumption of insignificance. If the cost mechanism relies on the monetary authority's unwillingness to completely accommodate oil price increases, then some argue that the problem is one of monetary policy rather than of oil price growth. Finally, even if oil price growth does produce inflationary costs, critics might question the link between marginal imports and the rate of oil price growth.

3.4 Monopsony Power and the Monopsony Premium

This section reviews the basis of possible U.S. monopsony power, and discusses some of the issues involved in the estimation of the monopsony premium. These issues concern how to represent the response behavior of other agents in the world oil market, particularly non-U.S. importers and OPEC. Estimates of this important import premium component alone are provided in section 3.5.

3.4.1 Monopsony Power

Monopsony power is the demand-side counterpart of monopoly power. If monopsony consumers, such as the United States, can reduce their levels of consumption below competitive levels, it is possible to drive down the world oil price and thereby benefit U.S. consumers, as well as consumers in other importing nations. There is significant disagreement about the extent to which monopsony power can be exploited due to potential retaliation by monopolistic producers and to what some interpret to be the very limited monopsony power of the United States.

Most analysts agree that the United States has at least limited monopsony power. However, they disagree about whether that power can/should be exercised. Some argue that the monopsony power of the United States is, in fact, very small. Others argue that the exercise of monopsony power, especially the adoption of an import tariff or quota, would call for retaliation on the part of oil exporters. This argument becomes more compelling given the widely-held opinion that OPEC has not exercised its full monopoly power and is at best acting as a "clumsy cartel." The exercise of monopsony power could lead to greater solidification of the oil cartel and thus result in world oil price increases.

To the extent that the United States has monopsony power and faces market power in oil supply, the failure to exercise monopsony power can be viewed as an opportunity cost. If monopsony power exists, U.S. imports of oil can be reduced by increasing the price of imports (i.e., a tariff) or by directly limiting the quantity of imports allowed (i.e., a quota). The impacts of a tariff or a quota depend on the elasticity of import supply, which is the subject of much debate. The greater the U.S. share of the world oil market, the greater the potential of the United States to exercise monopsony power.

The benefits of the successful exercise of monopsony power are of the same types as those associated with a reduction in monopoly power. In other words, benefits can be measured in terms of reduced direct costs (i.e., producer and consumer surplus losses and excess wealth transfers) and indirect costs (i.e., increased savings and a lower balance of payments deficit). A relevant question in assessing these potential benefits is establishing the correct point of reference. Potential monopsony power can be assessed relative to an optimizing monopolist or, for example, a "clumsy cartel." Obviously, one's assumption about potential monopoly power determines, to a great extent, the potential size of monopsony benefits. Another relevant question concerns the response of other importing countries. Will they act collectively with the United States to reduce consumption, will they not react, or will they take actions to actually increase their import levels? One's specific modeling approach and thus the estimated benefits of monopsony actions are very much dependent on the assumed reactions of oil producers and other importing countries.

3.4.2 Issues in Estimating the Monopsony Premium

Since the United States is a large consuming nation, in theory it could influence world oil prices by altering its level of imports. The monopsony premium is the marginal reduction in excess wealth transfer resulting from imports reduction. The "monopsony cost" of imported oil is the failure of oil consumers to collude and use their market power to recapture monopoly rents transferred to oil exporters (Murphy, Toman, and Weiss 1986:68). Broadman (1986:243) has described the monopsony cost effect as follows.

> "If an increase in the demand for imports leads to a rise in the world price of oil, the increase in price affects all imports .... In this case, the demand increase by the marginal importer produces an external cost by raising total payments abroad for oil imports by more than the price [it pays]."

In the exposition above on the import premium, the first term in the premium of Equation (4) corresponds to the monopsony premium. The monopsony premium is just the incremental change in world oil price induced by the import reduction times the level of imports:

$$\pi_{monops}(q_{iu}) = P_w^{\prime} q_{iu} \tag{8}$$

Here the prime symbol ($'$) denotes the derivative with respect to import levels. If η_{is} is the supply elasticity for oil imports, then the imported oil monopsony premium is also expressed as:

$$\pi_{monops}(q_{iu}) = \frac{P_w(q_{iu})}{\eta_{is}} \tag{9}$$

The social cost exceeds the private cost by P/η_{is}. This formula shows explicitly that the monopsony premium will vary with world oil price, import levels, and the price elasticity of net supply of imports to the United States. If the supply of imports is very elastic, the monopsony premium will be very small, and very large if supply is inelastic.

Estimating the monopsony premium has always been recognized as difficult because it requires the specification of non-U.S. response, and particularly OPEC response, behavior (Plummer 1981:6). Should the United States reduce imports through some policy measures, the following categories of response are possible:

- Non-U.S. Importer Responses
    - Market-based (some limited increase in demand as price drops, no policy change)

- Joint/Coordinated policy effort with United States
- Contradictory/Compensating policy

- OPEC Supply Responses

    - Maintain production at cartel-agreed levels
    - Partial (elastic, unitary elastic)
    - Cartelized - Full Offset (perfectly elastic)
    - Cartelized - Retaliatory (no supply curve)

Non-U.S. Importer Response Representation

For some premium estimates, the limited response of non-U.S. importers is approximated by fixed non-U.S. demand or supply. A more defensible and common approach is to include a market-based response by other importers and non-OPEC producers as prices fall, partially offsetting the monopsony power of the United States. The monopsony power of the United States and the size of the monopsony premium increases with the share of world oil trade comprised by U.S. imports.[15] The United States current and projected imports as a share of OPEC exports (non-OPEC net imports) is around 30 percent (U.S. DOE/EIA 1994), so the elasticity of non-U.S. import demand is an important parameter.

The marginal benefits to the United States of a coordinated policy with other oil consuming nations would be greater than those of a unilateral action, because of the global nature of the monopsony gains. The estimated import or consumption premium would be correspondingly higher, when the free market outcome is compared to a coordinated policy. Under coordinated policy action, non-U.S. importers are typically assumed to reduce their consumption in the same proportion as the United States [e.g., Stobaugh (1979)]. The early Energy Modeling Study [EMF-6 (1982)] considered the base monopsony premium or "buying power wedge" for both unilateral and joint OECD action. Tests with nine oil models all indicated that the base monopsony premium was 3 to 3.5 times larger given coordinated OECD action (Gately 1982:46). Joint action by the United States and other importers effectively increases the share of world oil trade under monopsony control, and increases the monopsony premium faster than linearly with the share of imports monopsonized (see previous footnote).[16]

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[15] The elasticity of net import supply can be decomposed into the elasticity of OPEC supply (η_{sO}) and the elasticity of net import demand from non-U.S., non-OPEC regions (η_{iN}):

$$\Pi_{monops} = \frac{P_w}{\eta_i}$$

$$\eta_i = \frac{\eta_{sO} q_{sO} - \eta_{iN} q_{iN}}{q_{iU}}$$

$$\Rightarrow \Pi_{monops} = \frac{P_w s_U}{\eta_{sO} - \eta_{iN}(1 - s_U)}$$

where s_U is the share of world net exports imported by the U.S.

[16] An extreme alternative to joint action by importers is the possibility of contradictory/compensating measures in other importing countries. Brown and Huntington (1994) note that Hoel's (1991) work on unilateral environmental actions also applies to unilateral oil conservation efforts: unilateral action by the United States could weaken its bargaining position with other importers who are considering comparable policy. In this case other countries could relax their efforts and, in theory, world oil imports could increase.

OPEC Supply Response Representation

Most estimates of the monopsony premium component assume some positive relation between price and OPEC supply, or include OPEC supply in a world import supply curve [e.g., EMF-6, Gately (1982), Broadman and Hogan (1986), Walls (1990), Huntington (1993)]. If OPEC is a true monopolistic supplier, then there is no well-defined conventional upward-sloping supply curve. A monopolist sets a price in inverse proportion to the elasticity of demand for its product, so in this case it may be more important for an import demand policy to increase demand elasticity than reduce the quantity demanded.

Nesbitt and Choi (1988) offer one polar alternative representation of OPEC supply. They apply a depletable-resource cartel model of OPEC behavior to estimate the effects of an import tariff and conclude "the degree of monopsony power that can be exerted by the United States is small, indeed almost minuscule" (Nesbitt and Choi 1988:46). They estimate that a $10.50 tariff such as that proposed by Broadman and Hogan would sharply reduce U.S. imports (by 30 percent in the first year) but would only reduce world oil price by $1.30/BBL. The insensitivity of world price to demand results from their assumption of a highly elastic world supply, and the treatment of oil supply according to dynamic depletable resource theory, in which price paths are strongly driven by the estimated resource base size and backstop price. Alternatively, viewing OPEC as a von Stackelberg monopolist suggests that while the elasticity of import supply may be ill-defined, the price charged will depend on U.S. consumption via the effect of U.S. consumption on OPEC's market share [Greene (1991), Greene and Leiby (1993)]. If the world could somehow reduce OPEC's market share enough, there would be pressure for prices to return toward competitive market levels.

Some critics of the monopsony premium approach question whether the exercise of monopsony power would be a justifiable interference in oil markets. If monopsony power can lower monopoly prices, why not use it to lower competitive market prices as well? Why not use it in all phases of international trade? According to standard theory, there are two good reasons: 1) competitive market prices produce an economically efficient allocation of resources; and 2) the indiscriminate exercise of monopsony power would likely shatter painstakingly negotiated free trade agreements. In short, there is too much to lose. But if free trade in competitive world markets is the goal, then judicious use of monopsony power against monopoly pricing may be a step in the right direction, while indiscriminate use of monopsony power against competitive producers is counterproductive [Greene and Leiby (1993)].

3.5 Numerical Estimates of the Monopsony Premium

As Table 5.4 shows, many of the early estimates of the monopsony premium [Plummer *et al.* (1982), EMF-6] are quite high, reflecting high base-price forecasts limited world supply elasticities. Broadman and Hogan (1986) carefully subdivided premium components, and estimated the monopsony premium assuming OPEC would drop price by $.50/BBL for each MMBD reduction of imports. Their optimal premium estimates of $1.50 - $5.00/BBL varied depending on base price and the magnitude of the disruption/security risk (the premium components interact when determining the optimal level of imports).

Some, but not all, recent studies are skeptical of policies to reduce imports, arguing that the elasticity of import demand in the rest of the world is fairly high [$\approx$1.8 Walls (1990)] and that with limited import share the United States is essentially a price-taker on world oil markets with no significant monopsony power. The effective elasticity of net supply to the United States estimated by Walls is greater than 12.0, given any world supply elasticity greater than 0.5. This stands in stark contrast to the implications of the set of oil market models surveyed in EMF-11 (1992), which exhibit long-run regional supply and demand elasticities of well under 1.0 and elasticities of net supply to the United States of between 2.0 and 3.0, given unitary OPEC supply elasticity [based on Huntington (1991)]. Huntington (1993) used a linear approximation of these models and estimated a range of optimal premia from $5 to $13/BBL (depending on the model), with an average of $9.[17]

The U.S. Department of Energy's Oil Market Simulation (OMS) model was included in the EMF-11 study. The 1994 version of the model was obtained to generate updated monopsony premium estimates. This model conforms to current EIA projections for oil price, and regional supply and demand levels. It also includes a partial-adjustment framework with smaller short-run elasticities and larger long-run elasticities. As in the Huntington (1991) report on the EMF-11 study, the OMS was run over two price paths to allow the estimation of long-run price elasticities for five world regions. The estimated elasticities are listed in Table 3.1, along with the EMF-11 implied elasticities for comparison.

Table 3.1: Estimated Long-Run Demand and Supply Elasticities Based on EMF-11 Models and Updated OMS-94

		DEMAND			SUPPLY	
Model	Year	U.S.A	Other OECD	Non-OECD	U.S.A	Other NonOPEC
OMS90 (20 yr)	2010	-0.327	-0.465	-0.149	0.340	0.170
CERI (20 yr)	2010	-0.441	-0.452	-0.455	0.196	0.144
HOMS (20 yr)	2010	-0.308	-0.381	-0.280	0.522	0.510
FRB-D (20 yr)	2010	-0.537	-0.528	-0.400	0.475	0.480
DFI (20 yr)	2010	-0.185	-0.532	-0.190	0.499	0.981
OMS94 (20 yr)*	2010	-0.187	-0.458	-0.223	0.604	0.144
OMS94 (10 yr)	2000	-0.124	-0.271	-0.129	0.245	0.081
OMS94 (1 yr)	1994	-0.122	-0.073	-0.037	0.050	0.021

Source for older models: EMF-11 WP 11.5, H. Huntington, Jan. 1991. OMS-94 elasticities estimated with a similar method.
*While some of these elasticities of OMS94 differ from those of earlier models, the monopsony premium depends on the OPEC response and on the elasticity of net demand for imports in non-U.S. regions. For OMS94, the non-U.S. elasticity of net demand for imports ≅ 0.68, which approximately matches OMS90. Also, tripling the elasticity of U.S. demand modestly lowers the high premium estimate in Table 5.13 from $4.60 to $3.91. Using -1.0 for the non-U.S. elasticity of net demand for imports (≅ CERI and HOMS long-run value, while FRB-D = -1.2) reduces the premium from $3.91 to $3.81/BBL.

The elasticity of OPEC supply was taken as exogenous, being either zero (no supply change in response to price movements), unitary, or perfectly elastic (supply adjusts to prevent any price change). The results of experiments with this model are summarized in Figures 3.2 through 3.6. Figure 3.2 shows that the base monopsony premium using long-run (20 year) elasticities lies somewhere between $0 and $6.50/BBL (1993$). Naturally, the premium is highest in the case where OPEC supply has zero elasticity: in this case OPEC holds production fixed, and the price falls

[17]Huntington's full premium estimates including disruption and monopsony premia range from $8/BBL to $14.3/BBL in 1988 dollars. Converting to 1993 dollars and subtracting the disruption premium of ~$3/BBL yields the reported range for the monopsony premia.

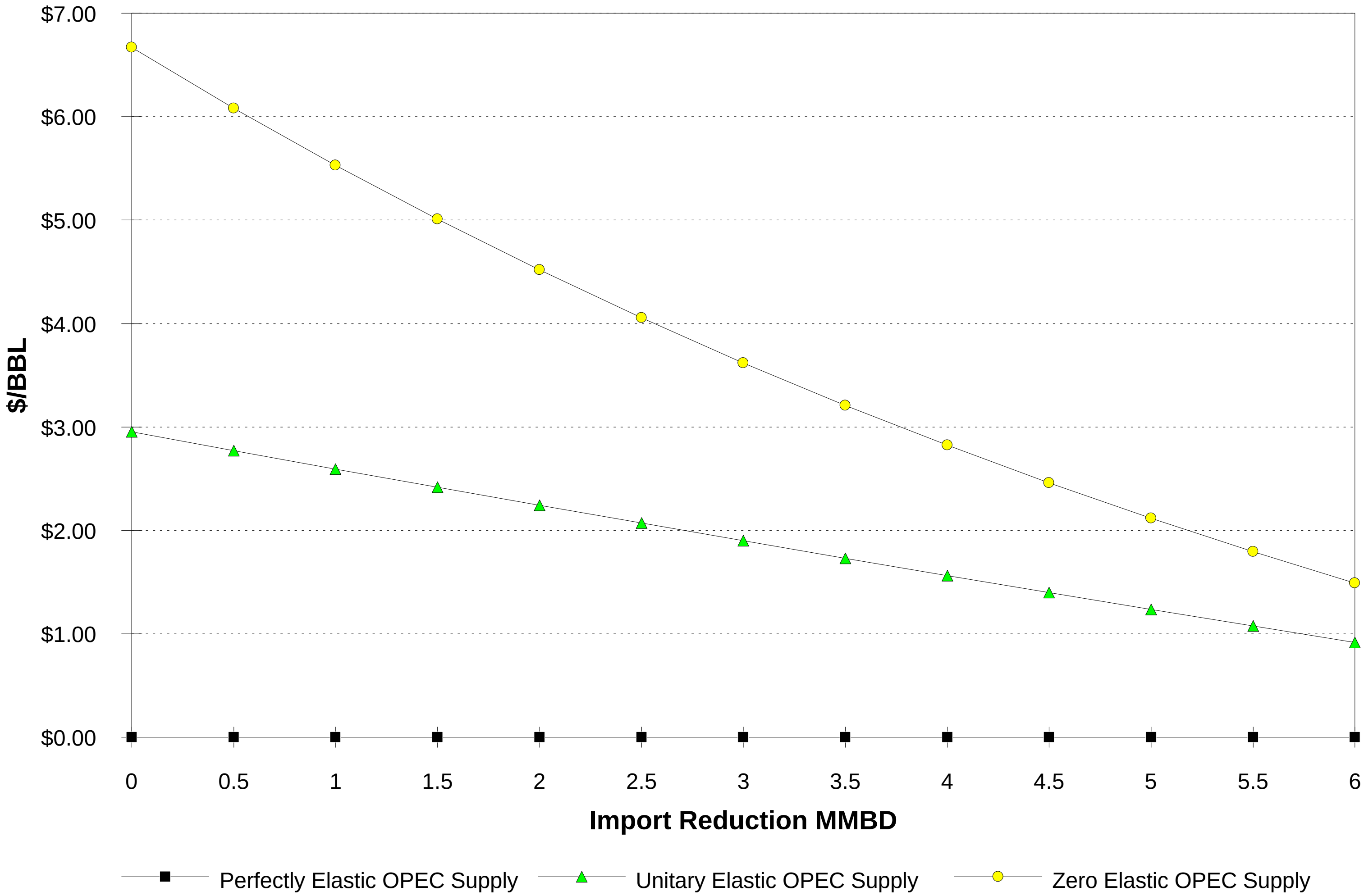
by the maximum amount. The amount that price falls depends on the elasticity of non-OPEC supply and demand. If OPEC supply is perfectly price elastic, the monopsony premium is zero. The result for the unitary elasticity of OPEC supply lies right in the middle, $3/BBL at base import levels. Note that the monopsony premium declines with the degree of import reduction, since the reduced import level and reduced oil price make it decreasingly valuable to limit imports.

Figure 3.3 reminds us that the net costs to U.S. consumers could be quite high if import demand is reduced in the face of a highly elastic world supply. In this case domestic production and consumption must make costly shifts with little or no gain in terms of lower world prices. This is the warning raised by Walls (1990), Nesbitt and Choi (1988), and Brown and Huntington (1994): we are uncertain about OPEC behavior, and import reduction policies *could* be costly (especially if done unilaterally).

The efficient level of import reduction is where the net marginal benefit of import reduction is zero. Figure 3.4 compares the monopsony premium with the *net* marginal benefit of import reduction. For this illustration, the net benefit number reflects only the monopsony benefits, and excludes other potential sources of import premium. The "net marginal benefit" is the monopsony premium minus the marginal social surplus loss due to reduced consumption. The latter overwhelms the former quickly, here in the zero OPEC elasticity case at around 1 MMBD of reduction. Smaller import reductions would be justified on monopsony grounds with a higher OPEC supply elasticity (as higher elasticities of other supplies and demands).

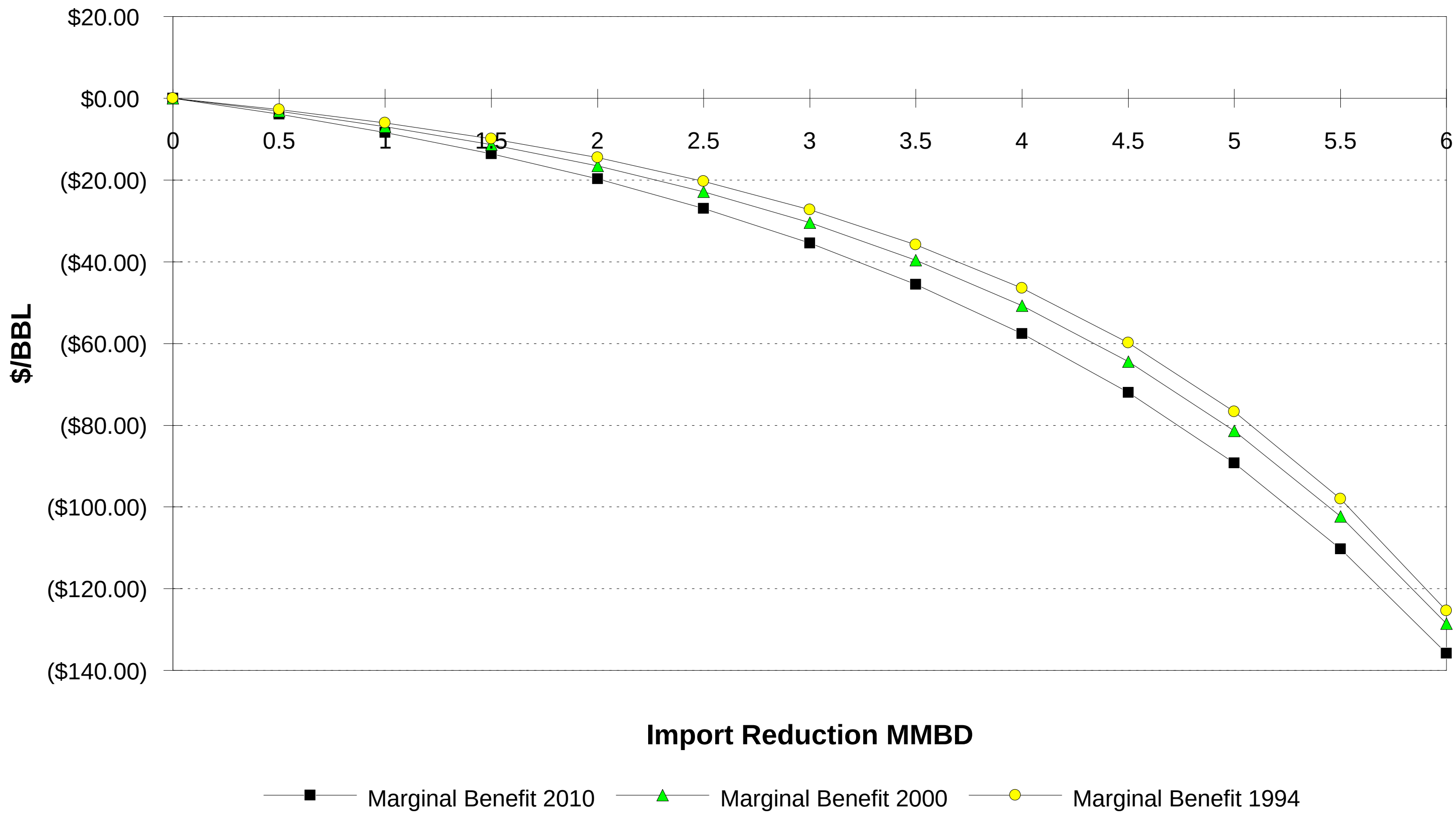
The monopsony premium, if non-zero, can be expected to increase over time. By the year 2010, due to projected increases in oil price and U.S. imports, the base monopsony premium is about doubled (for the unitary elasticity of OPEC supply case, see Figure 3.5). The monopsony premia estimated from the 1994 version of DOE's OMS model are much lower than those estimated from the 1990 version in the EMF-11 study (Figure 3.6). The difference is largely due to a substantial downward revision in both projected 2010 prices and U.S. imports.

Figure 3.2: 1994 Monopsony Premium Estimates for Different Long-Run OPEC Responses to Import Reductions



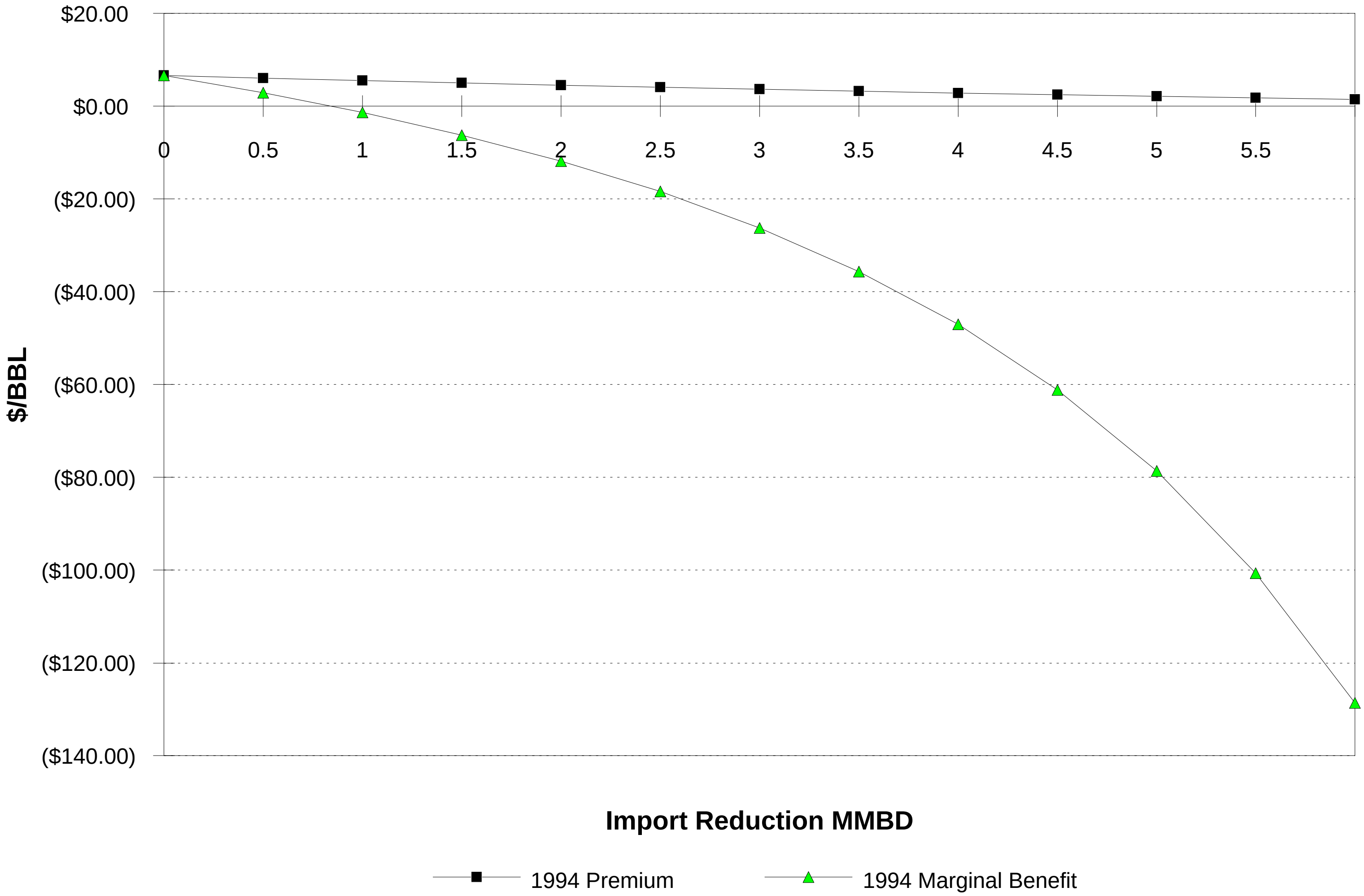
Note: Monopsony premium estimates depend critically on assuming OPEC supply response.

Figure 3.3: Losses From Import Reduction if Long-Run OPEC Supply Response Perfectly Offsets Import Reductions



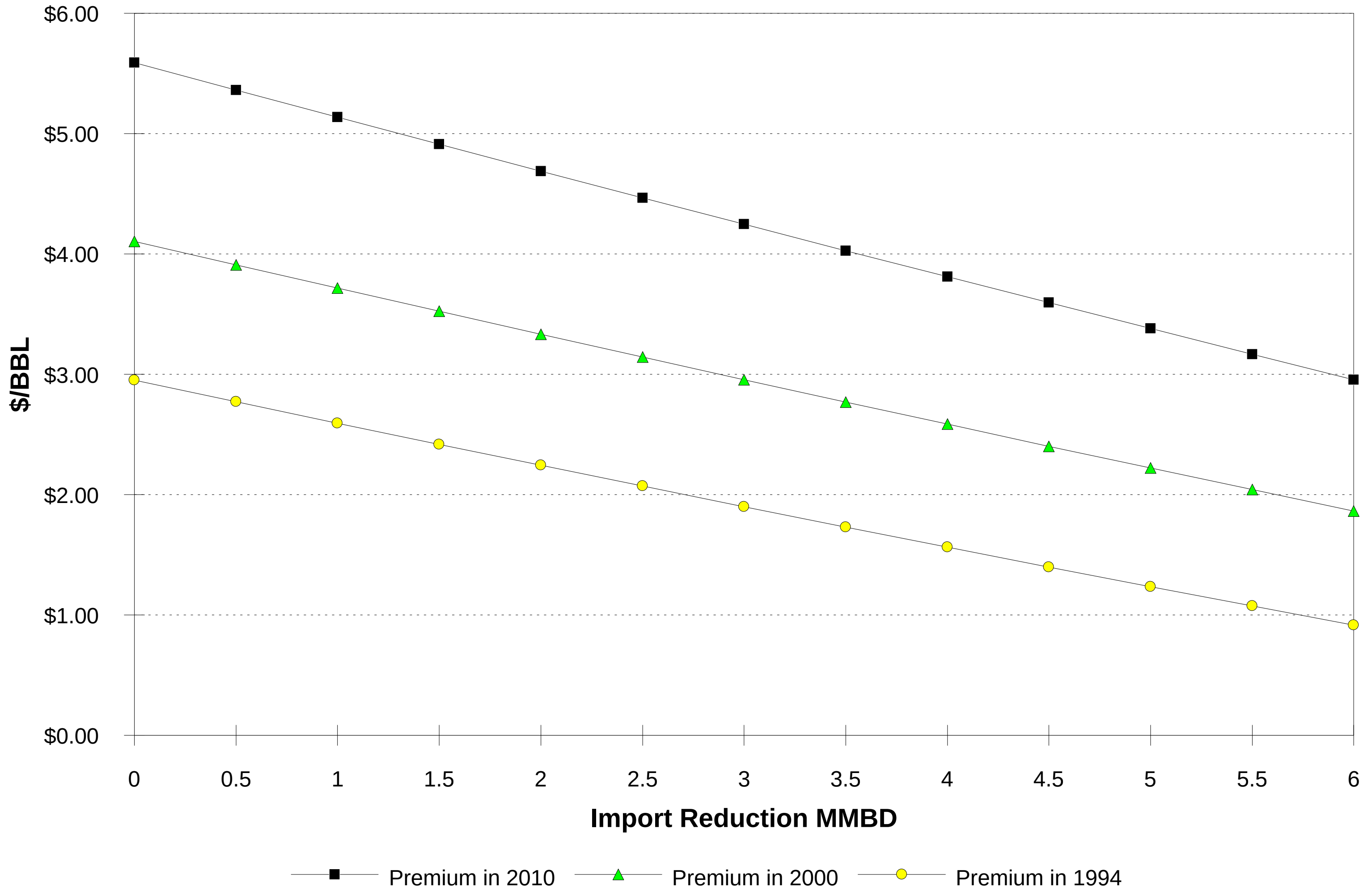
Note: Import reduction can impose enormous losses on consumers if OPEC response is to reduce output by the full amount of a U.S. import reduction, and prices consequently do not decline.

Figure 3.4: 1994 Monopsony Premium and Marginal Net Benefit for Long-Run Zero-Elastic OPEC Response to Import Reductions



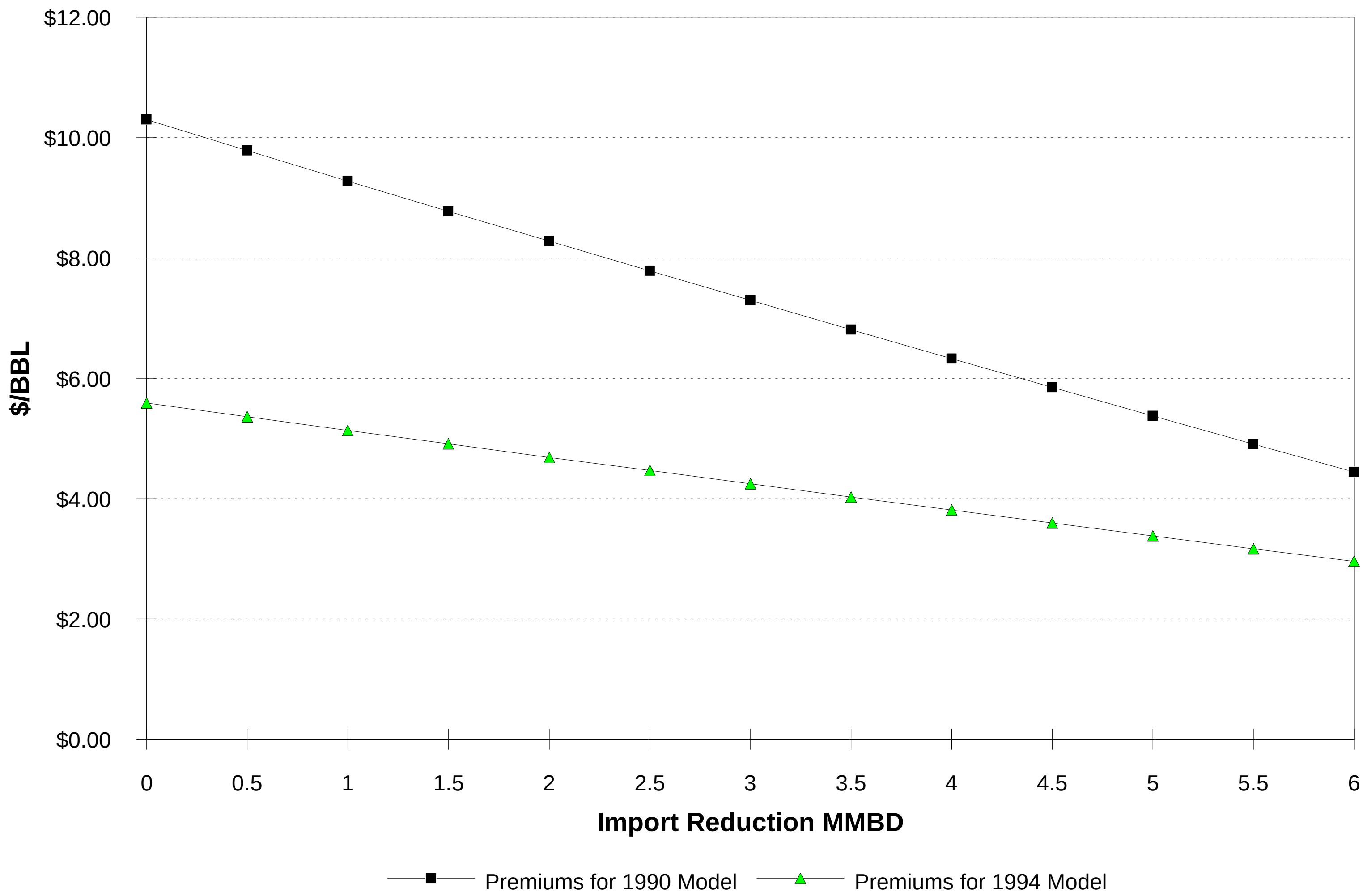
Note: The premium and the net marginal benefit or import reduction. Here the net benefit number <u>only</u> reflects the monopsony benefits, not other potential sources of the full import premium.

Figure 3.5: 1994, 2000, 2010 Monopsony Premium for Long-Run Zero-Elastic OPEC Response to Import Reductions



Note: The monopsony premia will increase over time, as U.S. imports and oil prices rise. (Based on EIA's 1994 OMS model).

Figure 3.6: Long-Run Monopsony Premia Based on Parameters for 1990 and 1994 International Energy Outlook



Note: The monopsony premia estimated from the EIA OMS model are much lower based on the 1994 version than the 1990 version, largely due to lower base oil prices in the year 2010.

4.0 DISRUPTION COSTS

This section describes three major types of cost that different oil analysts have claimed may be costs of oil supply disruptions. Further, it considers the portion of those costs which may vary with the volume of oil imports. In this sense, the section's ultimate focus is on the *marginal* disruption costs of oil imports, not simply the *total* costs of oil supply disruptions. Since the opportunity for private agents to hedge against oil price shocks such as the world has experienced since the 1970s is an important element in protecting against avoidable costs, we also discuss private hedging opportunities, including oil futures markets in particular.

4.1 Conceptual Issues in the Definition of Disruption Costs

Studies of the value of "oil security" for the United States typically have focused on the economic costs of supply interruptions or price fluctuations. Some analysts find a substantial value of oil security while others find less clear room for intervention policies. For example, Broadman & Hogan (1988) obtain expected benefit values between $6.80 and $8.50 per barrel, in 1993 dollars. In contrast, Bohi & Toman (1993) remain skeptical of numbers valuing oil disruption premia and question how much of the economic consequences of supply disruptions is a genuine externality and how much represents the predictable operation of markets or failure of macroeconomic policy.

The social cost components which may derive from disruptions or the risk of disruptions include:

- short-run loss in producers and consumers surplus (during a disruption);
- increased excess wealth transfer (during a disruption)[18]; and
- macroeconomic adjustment losses (short-run transitional macroeconomic consequences).

Typically, the costs of price shocks are divided into direct and indirect costs, although these terms are sometimes used differently by different analysts. Here, we define direct costs as those which accrue directly to oil markets. Included are incremental domestic oil production costs (known as deadweight losses), domestic consumption benefit losses, and increased payments for imports. Indirect costs result from the inability of the macroeconomy to either prepare fully for or adjust smoothly to oil price shocks. A host of mechanisms have been proposed by which these indirect disruption costs might arise, but most are only informally specified, and inadequately validated empirically. Consequently, analysts commonly group the hypothesized, indirect macroeconomic adjustment mechanisms together as unspecified adjustment costs, and seek empirical support for a simple functional form relating price increases to adjustment losses. This section reviews the direct and indirect costs of disruptions.

In estimating the import premium associated with each of these categories, we identify what is included in the cost component, and discuss the degree to which the component may vary with the level of imports. As with the noncompetitive market premium components discussed above, the estimate of marginal costs due to imports is conceptually simpler and more analytically sound than estimating total or average costs. This is largely due to the attribution problem: if the costs are not

[18] As mentioned previously, "excess wealth transfer" refers to transfers beyond the actual resource costs of the commodity, or what would obtain under competitive conditions.

influenced at the margin by imports, then how much of the costs are assignable to imports? On the other hand, the conundrum remains that certain "inframarginal" costs (such as macroeconomic disruption costs) occur, and are borne in total or on average, because we consume imports and because imports (or exports) link us to volatile world oil markets.

Each of the disruption components is an expected cost, that is, their possible values for alternative disruption sizes are weighted by their assumed probabilities. Most analyses of the disruption premium specify a probability distribution over the losses in supply quantity. Less common is the approach of specifying a probability distribution over price shocks without reference to supply [e.g., Huntington (1993)]. The advantages of the quantity-based shock approach is that it allows explicit modeling of how demand levels, demand price responsiveness, stockpiling, or other disruption offsets (U.S. DOE/ Interagency Working Group 1990) can mitigate the price consequences of the shock. It requires that a price disturbance have an identifiable cause and imposes the discipline of a fairly smoothly functioning market when estimating consequences. The advantages of the price-shock approach is that it is simpler, and admits the possibility of sharp short-term price disturbances stemming from only modest supply losses (e.g., inventory effects), sudden shifts in the political or national security situation, or changes in market structure or resource ownership [Curlee and Russell (1992)].

4.2 Oil Futures Markets and Other Private Hedging Opportunities

The present study implicitly includes a role for the futures market and other private hedging by assuming that 25% to 100% of the expected price increase from a low-probability oil price shock is effectively hedged and internalized. In view of the literature on the functions of futures markets in general and the characteristics of the oil futures markets in particular, we believe that this may be optimistic, giving excessive credit to futures markets' ability to hedge oil price shocks. Here we review some salient conclusions about futures markets in general, the operations of oil futures markets in particular, and the research literature on their performance. We conclude this subsection with a brief review of other private hedging opportunities.

The literature has identified two principal functions of futures markets, the provision of insurance for hedgers and a mechanism to incorporate information on future market conditions into current prices. The former function requires that futures prices contain a risk premium, which implies that futures prices are systematically biased relative to future spot prices. The latter function operates more efficiently the more accurately futures prices predict future spot prices. There is clearly a tension between these two functions, since the provision of hedging insurance distorts the information content which futures prices convey about expectations of future market conditions. The existence of a risk premium in futures prices and their unbiasedness characteristic as predictors are both empirical questions in the study of all futures markets--agricultural, metals, foreign exchange--not just those for crude oil and refined petroleum products. Newbery and Stiglitz [1981:185], summarizing the empirical literature, report that, "for many markets the hypothesis of zero bias is reasonable, but for thin markets or markets which for institutional reasons are unattractive to speculators the risk premium may be positive". Tomek and Robinson [1981:264] concur in their assessment of the empirical research on agricultural futures markets.

For storable commodities such as grains and crude oil, the principal contribution of futures markets is to coordinate and insure stock holding activities, offering relatively little price-stabilization insurance [Newbery and Stiglitz, 1981:191].[19] Newbery and Stiglitz note that, ". . .it should be stressed that futures markets do not generate the arbitrage benefits (that is, the benefits of transferring goods from low-value to high-value states) which the storage associated with price stabilization can produce" [1981, p. 188]. Noting that most *agricultural* futures contracts operate within the period six months ahead of the spot price, they suspect that the advantages to be gained from more distant contracts diminish to the vanishing point, relating the functioning of a futures market to the length of the production period (not just agricultural production). The oil futures markets also share this characteristic. Despite the growth in oil futures trading in recent years, in mid-March 1995, on the NYMEX, 44% of the volume of light sweet crude futures fall within 4 months of spot delivery, and 75% are within 10 months. (The futures markets for heating oil and unleaded gasoline continue to be much more heavily loaded toward the first three to four months than is the case for crude.)

Translating these general observations on futures markets to oil futures markets, it is useful to note that any risks hedged by futures markets are private risks. First, no divergence between private risk and social risk is involved. The creation of a futures market in crude oil does indeed eliminate the problem of a "missing market"--for private oil price risk--but it does nothing to help drive together private and social risk if private assessments underestimate social risk. Second, storage, not futures markets, moves oil from use in low-value periods to use in high-value (scarcity or disruption) periods. Third, while futures markets can reduce private price risk over a rolling six-month (or thereabouts) time horizon, they serve no clear function with regard to longer-term risks. They can alter short-run production and supply behavior of producers--principally oil refiners--but do not bring far future information into current pricing and capital investment decisions. Consequently, they are not able to help firms adapt their energy-using equipment to decade-horizon risks of oil supply disruptions. Finally, futures contracts are zero-sum exchanges of risk; one party to the contract wins at the expense of the other, so the economy as a whole does not avoid increased oil payments.

The futures market academic literature has focused to a great extent on the issue of the unbiasedness of oil futures prices as predictors of future spot prices. The null hypothesis, of course, is their efficiency in transmitting information to the spot market. The empirical results have been mixed. For the West Texas Intermediate (WTI) futures market, Dominguez [1989] accepted the efficiency hypothesis for three- to six-month futures and rejected it for one- and two-month futures, but noted the particular thinness of the market beyond the two- to three-month contracts. (In the Brent futures market, Weiner [1989] reported that fewer than 2% of the transactions from 1983 to 1989 involved contracts four or more months in the future.) Serletis and Banak [1990] found that forecasts based on current spot prices are commonly as reliable as those based on futures prices. Moosa and Al-Loughani [1994] criticize the econometric tests used in several other studies of oil futures markets. Using the most sophisticated time-series econometric techniques directed at the oil futures market to date, they find that WTI futures prices are both biased and inefficient forecasters of future spot prices, although they decline to generalize their findings to futures markets for other crudes, such as Brent.

As an additional theoretical problem in appealing to futures markets as the effective solution to externalities of oil price shocks, Toman has raised the question whether the volume of private hedging could be adequate. To the extent that there are macroeconomic consequences or other

[19] An alternative perspective is the limited ability of futures markets to provide price stabilization insurance is an indicator that the private costs of uncertainty are small.

social consequences of price shocks not fully included in private decisions, the social risk premium due to shocks will exceed the private risk premium. "A consequence of this possible gap between the premia would be lower investment by the private market in hedges against energy price fluctuations than is socially efficient" [Toman 1993:1199].

Additional private hedging opportunities also exist to safeguard against oil price shocks. Some of these, such as private stockpiling, have long existed as private options. Others, such as investment in flexible energy technologies, have emerged as part of the industrial world's response to the oil price shocks of the 1970s. Private stockpiling, to the extent that it is used as a private hedge against oil price shocks, is supplemented by the Strategic Petroleum Reserve. Regarding stockpiling, in 1973, OECD countries held 2.6 billion barrels of petroleum stocks, about 44 days of total world consumption. At the end of September 1994, OECD stocks amounted to 3.7 billion barrels, or some 57 days of world consumption. Government-owned reserves accounted for the full difference in stocks held between the two times (U.S. DOE/EIA 1995, Tables 1.1c, 1,3, and 1.6). The extent of the adoption of flexible energy technologies in the transportation sector and other petroleum-using sectors is an open empirical question. Altogether, the evidence on whether this package of hedging options is producing an efficient level of insurance is an open empirical question.

Despite the existence of efficient hedging or insurance markets, society is still concerned about the aggregate losses from shocks and, in general, would want to take cost-effective measures to reduce them. For example, even if adequate insurance markets and privately purchasable capital equipment exist to protect against floods, there may still be social value at the margin to measures which reduce the aggregate expected damage of flooding. Market failures which might produce a socially suboptimal quantity of hedging and other insurance may not be directly attributable to oil imports, but rather to seller market power or to oil consumption in general. Nonetheless, if the quantity of imports has a marginal impact on the macroeconomic cost of an oil price shock which itself is partly attributable to socially inadequate hedging, such a marginal impact is still attributable to import levels.

4.3 Direct Costs of Disruptions

4.3.1 Market Consequences of a Temporary Price Shock

Consider first the oil market (direct) consequences of a temporary oil price shock. Figure 3.1 (which was used to describe possible long-run noncompetitive price increases) may also serve as a graphical representation of the different direct disruption cost components. In this interpretation of Figure 3.1, it is assumed that the United States is a price taker on the world oil market, i.e., the domestic price is set by the world price. The oil import level is determined by the difference between short-run domestic oil supply, S_D, and short-run domestic oil demand, D_D. If the world oil price jumps from P_1 to P_2, domestic oil production increases, domestic oil consumption decreases, and oil imports decrease. In the long-run, changes in domestic production, consumption, and imports are defined by the long-run domestic supply and demand curves. However, in the event of a sudden and unexpected price jump, changes in production, consumption, and imports are defined by short-run domestic supply and demand curves which are more price inelastic (steeper) than the long-run curves.

The domestic oil market experiences three types of direct costs as a result of the price shock: (1) added production costs due to the expansion of higher-cost domestic supply (deadweight loss triangle A in Figure 3.1); (2) increased payments from oil importing countries to oil exporting countries (B in Figure 3.1); and (3) a consumer surplus loss (C in Figure 3.1). Horwich and Weimer (1984) present a detailed interpretation of the various geometric areas in Figure 3.1. They show that areas A and C (the change in social surplus) can be equated with the direct net losses in potential Gross National Product (GNP) from an oil price increase. Area B represents an increased domestic payment to foreign producers of oil. As such, area B entails no direct effects on domestic potential GNP, but is an additional payment to foreign producers and therefore should be considered a cost of a price shock to the United States. The area to the left of the domestic supply curve and partitioned by P_1 and P_2 is an increase in domestic oil revenues above any costs incurred in producing that given quantity of oil. This area is thus a transfer from domestic consumers to domestic oil producers. Although this transfer may raise equity concerns and may contribute to some indirect costs (e.g., see the below discussion on this "oil price drag") the transfer is not considered a cost of an oil price increase.

4.3.2 Calculating the Short-Run Loss in Social Surplus and Increased Excess Wealth Transfer During a Disruption

A common approach to estimating marginal reductions in disruption losses begins by calculating the loss from a disruption as the additional transfer of wealth abroad plus the deadweight U.S. social (consumer plus producer) surplus loss during the disruption. Together, these measure the "full-employment" (of labor and other factors of production) disruption loss. In contrast an early study by Plummer et al. used a compact macroeconomic model, ETA-Macro [Manne (1980)], to estimate full employment disruption losses. Sometimes the short-run losses in producer and consumer producer surplus are supplemented or replaced with an estimate of GDP macroeconomic adjustment losses, in which productive factors are unemployed due to short-run rigidities (see Section 4.4 below).

To calculate the social surplus losses and the increased excess wealth transfer during a price shock, we begin with a simple microeconomic representation of the oil market. Suppose a disruption occurs which causes a world price change ΔP and a shock-induced reduction in U.S. imports ΔQ_{iu}. In the linear approximation the social surplus and excess wealth transfer cost is given by the area of the trapezoid (see Figure 3.1):

$$C_{disr-FE} \cong \frac{1}{2}\Delta P(Q_{iu} - \Delta Q_{iu} + Q_{iu}) \tag{10}$$

These costs may be subdivided into the social surplus (or potential output) loss and the increased excess wealth transfer:

$$\begin{aligned} C_{disr-FE} &= C_{disr-SS} + C_{disr-WT} \\ &= \frac{1}{2}\Delta P \Delta Q_{iu} + \Delta P(Q_{iu} - \Delta Q_{iu}) \end{aligned} \tag{11}$$

The social surplus loss is the usual triangle under the import demand curve, whose area is smaller when U.S. import demand is less elastic and ΔQ_{iu} is small. When the oil price rises during a disruption, imports decline (by ΔQ_{iu}) but U.S. consumers pay more per barrel to foreign producers for the remaining imports (Q_{iu} - ΔQ_{iu}). Thus the excess wealth transfer is increased.

4.3.3 Calculating the Import Premium Components for Direct Disruption Costs

For the oil import premium approach, we are interested in the marginal expected disruption losses as imports change. The marginal change in (full employment) disruption loss due to an incremental change in base or imports is found by taking derivatives:

$$C'_{disr} = \frac{\partial C_{disr-SS}}{\partial Q_{iu}} + \frac{\partial C_{disr-WT}}{\partial Q_{iu}}$$
$$\frac{\partial \Delta P}{\partial Q_{iu}}\left[\frac{1}{2}\Delta Q_{iu} + (Q_{iu} - \Delta Q_{iu})\right] + \frac{\partial \Delta Q_{iu}}{\partial Q_{iu}}\left[\frac{1}{2}\Delta P - \Delta P\right] + \Delta \tag{12}$$

The third term on the right (ΔP) is the direct value of avoided higher import payments during a disruption, per barrel reduction of the pre-disruption imports level. This is captured by most import premium studies. Some studies [e.g., Huntington (1993)] simplify by omitting the possible secondary effects of long-run import policy on the disruption price increase ΔP or the shock-induced import reduction ΔQ_{iu}. These terms reflect the fact that changing the base level of imports, Q, may alter the volume of imports at risk to disruption, and the magnitude of the resulting price shock. If short-run elasticities are small, ΔQ_{iu} is small and the other terms are of second and higher order. Alternatively, Broadman and Hogan (1988) treat those secondary effects explicitly.

With the completely-inelastic short-run demand approximation (ΔQ_{iu}=0), the expected direct marginal disruption cost is just the expected disruption price change:

$$E[C'_{disr-WT}] \cong E[\Delta P] \tag{13}$$

This is exactly the result reported for Huntington (1993) in Table 5.4, who considers a 10 percent annual probability of a \$38 (1993\$) price spike.[20] This result raises an important point regarding the disruption premium. The import premium is intended to reflect the difference between the marginal social costs of imports and the marginal private costs of imports. In the case of the normal market premium, the marginal private cost is given by the world price of oil. The portion of disruption costs which are "internalized" in private decision making depends on the degree of foresight by private consumers *and* their opportunities to act on their expectations through diversification, contingent markets, or other means. Of the disruption cost components identified, the strongest case can be made for excluding some portion of the expected price change component ($E(\Delta P)$) from the premium, on the grounds that it could be anticipated and internalized by private agents. Nonetheless it is commonly included in the optimal premium calculations. The optimal premium is usually calculated as the difference between marginal benefits (demand price) P_{iu} and *normal market* world price P_w at the optimal import level Q_{iu}^* [e.g., Hogan 1981:293, Plummer et al. 1982:30,[21] Broadman and Hogan (1988), Huntington (1993)]:

[20] Huntington's results actually reflect the net present value of a long-run reduction in imports divided by the NPV of barrels reduced, given the annual price shock probability and various model assumptions about supply and demand dynamics. The NPV per discounted barrel over 20 years turns out to be about 10 percent greater than the result for the single year 2000.

[21] Plummer et al. (1982:30) are explicit about their assumption that the private sector does note fully anticipate the size or frequency of disruptions. They assert that given perfect foresight and flexibility, the direct microeconomic portion of the disruption premium becomes zero.

$$\pi^* = \pi(Q_{iu}^*) = \tau(Q_{iu}*) = P_{iu}(Q_{iu}^*) - P_w(Q_{iu}^*) \tag{14}$$

Alternatively, we could calculate the premium as the difference between marginal benefits and the *expected* world price $P_w+\Delta P_w$ at the optimal import level Q_{iu}^*:

$$\pi^* = \pi(Q_{iu}^*) = \tau(Q_{iu}*) = P_{iu}(Q_{iu}^*) - \left(P_w(Q_{iu}^*) + E[\Delta P_w]\right) \tag{15}$$

This latter formulation assumes that consumers are foresighted and have options, hence the private marginal cost includes both the normal market price and the expected price increase due to disruption. A useful approach is to parameterize the degree of consumer foresight and internalization, with the scalar ρ_E. The premium estimates assume that consumers internalize the portion $\rho_E E[\Delta P_w]$ of positive price shock direct costs for various choices of ρ_E.[22] We continue to assume that individual consumers do not recognize the marginal effect of their decisions on the magnitude of price shock, the degree of demand responsiveness during a shock, or any macroeconomic shock consequences.

The disruption premium components are defined as the expected value of the various disruption cost components. More generally, the disruption premia can be decomposed into the portions attributable to social surplus ($\pi_{disr\text{-}SS}$), excess wealth (rent) transfer ($\pi_{disr\text{-}WT}$), and transitional GDP adjustment losses ($\pi_{disr\text{-}GDP}$):

$$\begin{aligned}
\pi_{disr} &= \pi_{disr-SS} + \pi_{disr-WT} + \pi_{disr-GDP} \\
\pi_{disr-SS} &= \frac{1}{2} E\left[\frac{\partial \Delta P}{\partial Q_{iu}} \Delta Q_{iu} + \Delta P \frac{\partial \Delta Q_{iu}}{\partial Q_{iu}}\right] \\
\pi_{disr-WT} &= E\left[\frac{\partial \Delta P}{\partial Q_{iu}}\left(Q_{iu} - \Delta Q_{iu}\right) - \Delta P \frac{\partial \Delta Q_{iu}}{\partial Q_{iu}} + \rho_E \Delta P\right]
\end{aligned} \tag{16}$$

The disruption excess wealth transfer premium is analogous to the undisrupted market monopsony premium, except that the lower short-run elasticities during a disruption suggest that the monopsony wedge is greater (conditional on the occurrence of a disruption). The GDP adjustment portion of the disruption premium, $\pi_{disr\text{-}GDP}$, is discussed in the next section.

4.4 Indirect Costs of Disruptions

The GDP adjustment losses depend upon the size of the proportional price increase as well as the vulnerability of the macroeconomy to adjustment losses for a price shock of a given size. The vulnerability to adjustment loss is widely recognized to depend on the level of oil consumption rather than imports. Although consumption is a major determinant of the *total* shock effect on GDP

[22] Whether the existence and use of futures and forward markets actually *internalize* macroeconomic shock externalities rather than simply stabilize spot prices remains an open question, both theoretically and empirically. Internalization of macro shock *externalities* is a different matter from straightforward price stabilization, and involves the effects of individuals' separate decisions on other individuals' activities. Other hedging mechanisms, such as stockpiling and diversification, exist, but they existed during the previous oil price shocks, and presumably their effects operated then.

and has its own marginal effect, there is a *marginal* effect of *imports* as well. This arises because the pre-disruption imports level may affect the size of the price shock, as the social surplus portion of equation (16) shows. In this analysis there are two mechanisms by which this may occur. First, changing the level of imports may alter slightly the distribution of oil disruption quantities, that is, marginally change the expected size of the oil shortfall by either creating excess capacity or reducing the supply flows at risk of disruption. Second, changing the predisruption level of imports changes the starting points on the oil import supply and demand curves from which the disruption deviates. As a result of either of these mechanisms, the proportional size of the price shock may be diminished.[23]

4.4.1 Possible Mechanisms by which Indirect Disruption Costs Could Arise

Indirect costs can arise in addition to the direct costs, due to the limited ability of the macroeconomy to adjust smoothly to the price shock. The extent to which these costs are the result of a market failure, however, is debatable. The costs are based on the assumptions that: (1) oil plays a crucial role in overall economic activity; and (2) our macroeconomy's short-term adjustment possibilities are limited by various institutional constraints. Several mechanisms by which adjustment costs may arise in response to a price shock have been discussed in the literature over the past two decades, not all of which remain widely accepted among students of the problem. For thoroughness, we give a brief noncritical overview of potential costs which have been suggested in the literature. We review these more thoroughly in the subsequent sections.

Inflexible Wages

The most important short-run adjustment cost is based on the possibility that real wages will not adjust to maintain full employment when there is an oil price shock. An increase in oil prices will decrease the consumption of oil and will lower the marginal productivity of labor. If real wages can not be reduced, employers will decrease employment, and GNP will be reduced.

Adjustments to New Relative Prices

In addition to wage rigidities, adjustments to changes in the relative price structure for all energy sources and all goods and services may occur also. While the economy is adjusting constantly to new relative prices, the notion is that oil is of such great importance to the total economy, that the adjustment costs associated with an oil price change are of special significance. GNP losses may occur as the economy adjusts to the new long-run demand mix.

Premature Obsolescence of Capital Stocks

An oil price shock may lead to premature obsolescence, or otherwise inefficient utilizations, of energy-using capital stocks. New energy prices may cause some capital stock elements to be no longer competitive with more efficient capital goods; and some capital stocks may become obsolescent prematurely because of a general decline in the demands for expensive, energy-intensive products. A reduction in capital services will result in a reduction of potential domestic output.

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[23] It has also been argued that reduced imports could lower the *probability* of opportunistic price shocks, by reducing cartel market share and the value of exploiting short-run market power (e.g., Suranovic 1994, Greene 1991, Wirl 1985, Fromholzer 1981). This possible effect is *not* included in this study.

Oil Price Drag

Horwich and Weimer (1984) identify reductions in aggregate demand from the "oil price drag" as a potential problem (sometimes called "leakage"). As indicated in Figure 2.2, a price shock will transfer wealth from domestic consumers to domestic and foreign producers.[24] The oil price drag results from the inability of domestic and foreign oil producers to spend the incremental revenues they receive during the price shock. Aggregate demand therefore is reduced temporarily.

Domestic Inflationary Pressures

Higher oil prices will result in short-term domestic inflationary pressures. There is disagreement, however, about the existence and extent of this problem and whether an oil price shock will lead to a one-time inflationary jump or be a catalyst for a longer-term inflationary spiral.

Reduced Domestic Savings and Investment

Some analysts [e.g., Broadman, (1986)] suggest that an oil price shock can lead to reductions in domestic savings and investment and thus reduced capital formation. Lower economic growth will follow. While earlier theories of economic growth indicated little effect of the savings rate on the growth rate, recent theories of endogenous economic growth have revealed more important links between savings and growth [e.g., Romer (1986)].

Estimating each of these potential indirect costs without overlap poses serious challenges. Also challenging is the disaggregation of adjustment costs that are directly associated with oil markets and adjustment costs that occur in the macroeconomy.

An important distinction among these disruption cost components is that some depend largely on import levels while others depend on the level of total oil consumption. Although the excess wealth transfer associated with a price shock is a direct function of oil import levels, surplus losses and the indirect costs of a price shock are determined primarily by the level of domestic oil consumption. The possible exception to this statement is the relationship between the level of oil imports and the oil price drag (i.e., shifts of revenues to foreign producers may be more damaging than shifts to domestic producers).

4.4.2 Issues in Macroeconomic Adjustment Costs: Short-Run, Long-Run, and Policy

The remarkable correlation and apparent causal link between oil price shocks and subsequent economic recessions has received extensive attention from energy economists [e.g., Hamilton (1983), Hickman (1987), Bohi (1989); see Toman 1993:1192-8 and Mork 1994 for surveys].[25] As discussed in the previous section, the existence of monopoly induces both a transfer of wealth and a loss of social surplus (potential GDP). Of course the continuing transfer and GNP loss from

[24] As mentioned previously, "excess wealth transfer" refers to transfers beyond the actual resource costs of the commodity, or what would obtain under competitive conditions.

[25] Much of this discussion in this section is based on Greene and Leiby (1993).

monopoly will rise when a price shock occurs because the price increase is even greater.[26] But oil price shocks also generate what Pindyck (1980:2) has termed "secondary" effects or what Huntington and Eschbach (1987, p.201) call "macroeconomic adjustment costs." Macroeconomic adjustment costs arise because imperfect adjustment in the short-run to a major oil price increase will cause the economy to contract more than is necessary in the long-run (more than the loss of potential GNP). Wages and prices will not adjust immediately to the new price of oil for a variety of reasons, including cost-of-living provisions in labor contracts and entitlement programs. Also, substitutions of other energy sources and other factors of production for oil will take time because of the durability (economic value tied up in) energy-using equipment.[27] Hickman (1987:141) explains: "Stability considerations suggest that prices, and hence output, will probably overshoot the long-term equilibrium . . . ." The GNP level that can be reached in the short-run is necessarily lower than that which could be reached if the economy were able to adjust at the long-run, optimal prices and wages. Figure 4.1 illustrates how the economy will overshoot its long-run loss of production possibilities by moving first to a point that is long-run inefficient (2), and then to a point that is on the new long-run production possibilities frontier (3).

Short-term macroeconomic adjustment costs occur in addition to the longer-run loss of potential GNP. Macroeconomic adjustment costs are a temporary (several year) excess loss of GNP, that is suffered in addition to the loss of potential GNP due to the increased economic scarcity of oil. Huntington and Eschbach (1987:200) also emphasize that excess wealth transfers and the oil price shock losses of real GNP measured by macroeconomic models are additive. Their argument that macroeconomic models ignore the oil wealth loss arises from the way GNP is measured and is essentially an accounting problem [see also Toman (1993)].

The level of macroeconomic adjustment losses is an empirical question. In practice, the losses may also depend on the choice of fiscal and monetary policy. Oil price shocks may produce governmental policy responses that exacerbate the problem. If a deflationary monetary policy is pursued to deal with the effect of the oil price shock on inflation (rather than an expansionary policy to accommodate the price increase and return the economy as quickly as possible to full employment), one could argue that part of the cost should be attributed to monetary policy rather than to the price shock itself (e.g., Bohi 1989:84-85). Attempts to prevent the redistribution of income (e.g., due to "windfall" profits) may also produce excess economic costs. Some analysts attribute most of the historical GDP loss following disruptions to misguided macroeconomic policy [e.g., Bohi (1989), Bohi and Toman (1993)]. However, others maintain that a tradeoff must be made between the inflationary effects of accommodation and the output reductions of fiscal and monetary control [Nordhaus (1980), Rasche and Tatom (1981), Broadman and Hogan (1988), Huntington (1993)]. Thus the macroeconomic adjustment losses will depend in part on the extent to which temporary inflation can be tolerated and an accommodative policy may be pursued.[28]

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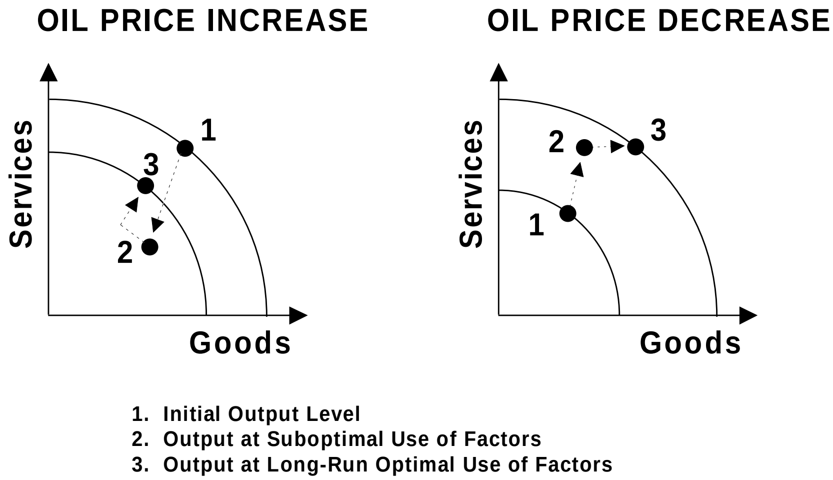
[26] Broadman, (1986 p. 245), makes this same argument in terms of the "monopsony wedge" effect.

[27] Numerous other types of macroeconomic costs can result from an oil price shock. These include "leakages" in trade that may affect the United States' balance of payments, as well as producing a shortfall in aggregate demand. This leakage or "fiscal drag" effect depends on oil exporters' (and domestic oil producers') short-run marginal propensity to spend. Huntington (1993) notes some evidence that oil exporters are attracted to dollar-denominated assets as a short-run means to hold new-found wealth (see Hickman et al. 1987:41), so that the fiscal drag may be limited. Another type of macroeconomic cost can result from consumption-investment shifts due to the international and domestic redistribution of income. To the extent that the new distribution of oil revenues results in a greater or lesser propensity to consume, this too can affect aggregate demand. Price shocks may also affect the willingness of producers to invest in capital equipment, thus affecting the rate of economic growth. For a discussion see, e.g., Goulder (1985).

[28] The estimation approach of Broadman and Hogan [1988] explicitly includes the proportion of inflation accommodated as one of its parameters. However, this is used for the long-run inflationary costs, not disruption costs.

Figure 4.1: Effects of Oil Price Shock-Induced Scarcity on Short-Run and Long-Run Output



It is important to distinguish between these short-run *adjustment* costs and the possibly permanent reduction in potential GNP which would be caused by a rapid, but long-term, change in energy prices, effectively shrinking the production possibilities of the entire economy. Hamilton (1988) has developed a real (i.e., non-monetary) business cycle model which illustrates how the effect on the economy is not limited by the dollar share of energy in GNP but rather on the dollar share of products whose use depends importantly on energy, i.e., on the elasticity of substitution between energy and other inputs and products in production and consumption. Macroeconomic adjustments also include financial rearrangements which may appear to be far removed from oil--effects on balance sheets of both firms and individuals; portfolio effects in the stock and bond markets--which may reduce aggregate demand or shift its sectoral composition in ways that cause dislocations in various parts of the economy.

4.4.3 Direct Empirical Evidence on Macroeconomic Adjustment Costs

Recently, some questions have been raised about the existence and magnitude of the macroeconomic effects of oil price shocks. It is useful to review the literature regarding these effects, to weigh the arguments. A number of studies have found significant and apparently causal correlations between oil price shocks and macroeconomic performance in the United States and in other countries: Mork and Hall (1980a, 1980b), Bruno and Sachs (1982, 1985), Hamilton (1983, 1985), Burbridge and Harrison (1984), Davis (1984, 1985), Santini (1985), Loungani (1985, 1986), Gisser and Goodwin (1986), Mork (1989), Tatom (1993), Mory (1993), Mork et al. (1994), all of which find significant effects of oil price shocks, although commonly differing across countries and among oil price-shock episodes. Estimated values of the oil-price elasticity of GNP for the U.S. have ranged between -0.02 and -0.06. Analysts have obtained different results regarding the symmetry or asymmetry of macroeconomic response to oil price shocks, but as closer attention has been paid to that question, econometric evidence has pointed toward some degree of asymmetry for most, but not all countries examined. Gilbert & Mork (1986) have developed the theoretical underpinnings for asymmetric aggregate responses, highlighting that an economy incurs *adjustment* costs regardless of the direction of an oil price shock. According to Lilien's (1982) dispersion hypothesis [see also the model of Hamilton (1988)], any relative price shock which requires reallocation of labor (possibly other factors as well) involves periods of unemployment as specialized factors search or retrain. Mankiw (1990, p. 1654), in summarizing the empirical research on the hypothesis, notes that the accompanying reduction in income may lower the demand for all products during such a period of labor reallocation. Energy price shocks have been found to be the principal type of external disturbance which propagates such a process of unemployment (Loungani 1987). In the case of a price decline, such as occurred in 1986, whether the aggregate GNP response is positive (symmetric to the case of positive price shocks) or negative (asymmetric) is an empirical matter of whether production frontier effects (expansion of full-adjustment production opportunities when oil prices fall) or adjustment costs dominate.

Toman (1993), relying on Bohi (1989, 1991), and Bohi and Toman (1993) have questioned these findings. Bohi's monograph (1989) and corresponding article (1991) examined output, employment, and energy intensity in some twenty 3-digit ISIC (International Standard Industrial Classification) industries in Germany, Japan, the United Kingdom, and the United States over the two periods 1973-75 and 1978-80, and using zero-order correlation analysis found no strong or consistent correlations between energy intensity and industry-level activity. He also reported finding no evidence of wage rigidity during these periods. Toman (1993, p. 1198), relying principally on the negative findings of Bohi, concludes his assessment of macroeconomic effects of oil price spikes with, "While Bohi's analysis does not represent the last word on the subject, it does shift a considerable burden of proof to those who would favor a strong link between energy price shocks and macroeconomic losses."

Despite the theoretical exposition of asymmetric macroeconomic responses to oil price shocks offered by Gilbert & Mork (1986), Toman considers the evidence of asymmetry in macroeconomic response to oil price drops as casting further doubt on the econometric findings of strong effects of price spikes. In a separate discussion of asymmetric macroeconomic responses to oil price shocks, Bohi and Toman (1993, p. 1104) may underemphasize Mork's (1989) important confirmation of Hamilton's (1983) econometric analysis of the macroeconomic consequences in the United States of oil price shocks between 1948 and 1980: "Hamilton looks at correlations between energy prices and GNP before 1981 and concludes that higher energy prices cause recessions, while Mork finds that the same statistical methods applied to data extended through 1986 give a different impression." In fact, Mork's (1989, p. 743) assessment of his own findings is, "The results now strongly confirm a large negative effect of oil price *increases*. . . . The coefficients for price *declines*, on the other hand, are smaller and of varying signs." Clearly, Bohi's largely negative findings regarding industry-level responses during the two major oil shocks of the 1970s raise important questions which warrant further econometric investigation with more sophisticated techniques.

Bohi and Toman (1993) attribute most of the apparent macroeconomic cost following oil shocks to inappropriate macroeconomic policy, although they have not econometrically tested such an hypothesis. Nonetheless, some of the more recent studies (e.g. Mory 1993), attempt to account for monetary policy in their estimates, yet still find losses after oil price rises. Furthermore, Hamilton's (1983) findings of a stable relationship between oil price shocks and GNP from the end of World War II through 1980 raises questions about Bohi's policy explanation for the 1973-74 and 1979-80 shocks.

The important distinctions between the Bohi study and other contradictory empirical work are in the degree of aggregation and the econometric methods used. To shed new light on this question of the macroeconomic cost of oil shocks would require applying sophisticated econometric techniques to data at various levels of sectoral and regional aggregation.

4.4.4 Evidence on Macroeconomic Adjustment Costs from Simulation Models

The evidence on the magnitude of these adjustment costs comes in two forms, direct empirical studies of the effects of oil price shocks on aggregate economies and simulation studies of energy in the aggregate economy. Over the past fifteen years, regression analyses of oil shocks and macroeconomic performance consistently have shown strong, negative impacts of oil price increases on GNP and employment (some of these studies are referenced below). The strength of the effects varies among industrialized countries, and more recently it seems to be emerging that the effects are asymmetric, that is while sharp increases precipitate sharp or mild recessions, price drops do not cause economic booms. Different models, different time periods and different data series have been used in obtaining these results, so while some differences are to be expected, the consistency of the negative macroeconomic effects found across the corpus of these studies reinforces the findings of any individual study.

The simulation models offer another kind of evidence since, admittedly, little comes out of such a model which is not put into it by the modeler. The contribution of the simulation studies to assessment of the macroeconomic adjustment cost of oil price shocks comes not from the appearance of the effect, since that is built into the models, but rather from the ability to examine in a controlled fashion the magnitudes of effect deriving from particular combinations of parameters reflecting various characteristics of the oil market and the aggregate economy. The parameter values used in the simulations are derived from empirical experience--price elasticities of demand for oil, etc. The results of these models should not be accepted uncritically, as their creators and users themselves warn. Bohi and Toman (1993, p. 1104) believe that, "The main source of skepticism about the results of these models is that the equations of the models employ parameters estimated from limited experience with price shocks over the 1950 to 1980 period." Hamilton (1983) found substantial continuity of the GNP-oil price shock relationship between the period from 1949 through 1972 and the period from 1973 through 1980, and Mork (1989) found that extending the later period through 1986 strengthened the relationship Hamilton found between oil price increases and GNP. Another problem for these energy-economy simulation models lies in assessing their correspondence to purely theoretical counterpart models. The simulation models are empirically implementable compromises of accepted macroeconomic models using the IS-LM curve, or a related, framework, but it is unclear exactly what macroeconomic specifications underlie various equations in the simulation models. Eastwood (1992) has found the numerical pattern of wage adjustment in the EMF-7 modeling study (Hickman et al., 1987) consistent with a Phillips-curve model of real-wage stickiness, and he raises the question whether that specification parallels the U.S. empirical experience. Similarly, the international linkages of the simulation models generally do not distinguish between tradable and non-tradable goods, a distinction which has been found of critical importance in open-economy macroeconomic models.

4.4.5 Methods for Simulating the Macroeconomic Adjustment Costs of Disruptions

Early studies used a multiplier approach to estimate indirect adjustment costs. As mentioned above, the Plummer et al. study used a compact macroeconomic model to estimate the benefits of oil consumption. During a simulated disruption, ETA-Macro provided the value of short-run full-employment output. Indirect macroeconomic adjustment losses associated with wage and price rigidity and unemployment were estimated by applying a multiplier to the estimated loss in full-employment output.

More recently, a common approach for estimating the frictional or adjustment losses in GDP is to assume a constant elasticity form for GDP with respect to oil price shocks:

$$GDP = GDP_0 \left(\frac{P}{P_0} \right)^{-e} \tag{17}$$

where GDP_0 and P_0 are undisrupted levels of GDP and price, and e is the percentage change in GDP per percentage change in oil price. This approach came into wide use [e.g., Leiby and Lee (1988), Broadman and Hogan (1988), DOE/Interagency SPR Study (1990), NES Oil Externalities Draft (1990)] after the Energy Modeling Forum 7 (EMF-7) study, in which estimates of e were generated. This method is usually presumed to incorporate also any short-run macroeconomic losses due to the inflationary effect of a price shock.

An important issue for the present purpose is whether possible GDP adjustment costs would imply a premium on marginal import use. The macroeconomic adjustment costs due to disruptions are widely believed to be proportional to levels of oil consumption rather than imports. Since macroeconomic adjustment losses are not necessarily a function of imports *per se*, they may not vary with incremental import changes (Plummer et al., 1982:29; Huntington 1993:16). Previous studies of the import premium have adopted one of three ways to deal with this issue:

1. Omit GDP adjustment costs of disruptions altogether, since they depend on consumption levels and are not expected to change at the margin with imports, at least to a first order approximation [e.g., Huntington (1993)]. This approach implies that consumption remains fixed, and import reductions must be achieved by domestic supply increases. The accuracy of this first-order approximation is an empirical issue.

2. Assume that some fraction (ρ_c) of the marginal imports change is accomplished by changing domestic consumption, and include the appropriate share of GDP adjustment losses in the premium [e.g., Plummer et al. (1982:30) who assume ρ_c=1 to establish a maximum estimate of the import premium. Another related approach was used by Hogan (1981:292) who included a multiplier m on the direct disruption costs to account for indirect macroeconomic costs, thereby implying a non-zero marginal indirect macroeconomic cost].

3. Include an explicit formulation describing how marginal import changes alter the determinants of the GDP adjustment losses, and indirectly affect the level of those losses [e.g., Broadman and Hogan (1988) assume that adjustment losses depend on the relative size of the price shock and include terms for the marginal effect of pre-disruption imports on the base price and size of the price shock].

Because the purpose of the present study is to assess the marginal external costs of oil imports, the third approach is adopted in the numerical calculations presented in Section 5.

5.0 NUMERICAL ESTIMATES OF THE OIL IMPORT PREMIUM

This section reviews previous estimates of the oil import premium reported in the literature; re-calculates Broadman and Hogan's (1988) detailed import premium components using up-dated information on price, GDP, market shares, etc.; and offers revised premium estimates relying on a restricted group of external cost components. The revised estimates are based on the Broadman-Hogan methodology, excluding some of its more controversial cost components.

5.1 Previous Estimates

This section reviews, in tables, the methodology, scenarios (parameter assumptions), and resulting estimates of the oil import premium from seven studies. The premium estimates are broken down into the Noncompetitive Market and Disruption components, with more detailed cost components provided where available.

Table 5.1: Economic Cost Components - Methodology

Component	Plummer et al., (1982)	Broadman and Hogan (1986, 1988)	Huntington (1993)	NES Oil Externality Draft (1990)	Miscellaneous
Monopsony Effect (Normal Market Increased Prices and Excess Wealth Transfer)	Y	Y - uses isoelastic LR curves	Y - based on multi-year model effects	N	Y [EMF-6 (1982), Walls (1990)]
LR Social Surplus Loss	N - (small)	Y - (marginal loss is demand price)	Y - (marginal loss is de-mand price)	N	
LR Potential GNP Loss	N - (small)	N	N	N	
LR Balance of Payments Costs	N	Y - exchange rate varies with import	N	N	
LR Inflationary Costs	N	Y - Phillips Curve & Okun's Law	N	N	
Cost of Policy: SPR	Y - includes monopsony effect of SPR acquisitions	N	N	Y - no margin-al cost; report average cost	
Military and Na-tional Security Costs	N	N	N (no mar-ginal effect of imports)	Y - no margin-al cost; report average cost	Hall: est. linear function of imports
SR Social Surplus Loss in Disruption	Y - use SR macro model	Y	Y	N	
Increase Excess Wealth Transfer During Disruption	Y	Y	Y	Y	

Table 5.1: Economic Cost Components - Methodology (cont.)

Component	Plummer et al., (1982)	Broadman and Hogan (1986, 1988)	Huntington (1993)	NES Oil Externality Draft (1990)	Miscellaneous
Macroeconomic Losses During Disruptions (Adjustment Costs)	Y - (but minimal marginal effect of imports)	Y - price elastic GDP form, marginal effect of imports	N - (assume no marginal effect of imports)	Y - (simple GNP-elasticity form)	
SR Balance of Payments Costs/ Leakage or Fiscal Drag	N	N	N	N	
Dynamic Considerations	SR elasticity of substitution for oil is 10% of LR. Dynamic stockpile management	Different single-period SR and LR elasticities of demand and supply	Imposes LR shifts in U.S. production or consumption, 1989-2010. Calculates discounted costs per discounted barrel shift.	Multi-period SPR size model with independent sequential SR equations	
Basic Approach, Other Notes:	Combines insights and general results from a suite of related studies on oil modeling, monopsony wedge, and SPR value. Marginal premia computed at *base* import level.	Integrated framework considers marginal variation in each component with imports, computes premium at *optimal* level of imports.	Results from 7 oil models from EMF-11, for two fixed price paths, benchmark linear import supply and demand. curves. Then calculates year 2000 premium at *optimal* import level.	Focuses on non-market costs of *imports* due to disruption risk. Uses SPR size model from DOE 1990 study. Premium computed at *base* (non-optimal) import level, on $/BBL *consumed* basis.	

Table 5.2: (Base) Assumptions For Noncompetitive Market Economic Cost Estimates

Parameter	Plummer et al. (1981)	Broadman and Hogan (1986, 1988)	Huntington (1993)	NES Oil Externality Draft (1990)	Miscellaneous
Base Prices	Unknown	$27.00 (1985$)	Base prices flat at $18 (1988$)	IEO 90 projections	
U.S. Demand and Import Levels	Imports 6.3 MMBD	Imports 6.0 MMBD	Imports vary by EMF model, 9-22.9 MMBD in year 2000, average = 15.8 MMBD	IEO 90 projections	
U.S. Demand and Supply Price Responsiveness	Assume demand declines with imports	Constant elasticity LR (0.5)	Assume linear net import demand	Fixed normal market levels	
Non-U.S. Demand and Supply Price Responsiveness	Unknown	Part of linear import supply	Assume linear net import supply	Fixed normal market levels	Walls: demand elasticity 1.8
Non-U.S. Demand and Supply Policy	No change	No change	No change	Foreign stock draws, else no change	Walls: none
LR OPEC Supply Behavior	Mix of 3 Gately models	Part of import supply curve, slope $.50/BBL/ MMBD	Replaced with assumed fraction (~20%) of tariff shifted to foreigners	LR monopsony calculation, elasticity 0.0	Walls: 0.5-10 elasticity
Disruption Deterrence	None	None	None	None	
Discount Rate	8%	N/A	5%	10%	

Table 5.3: (Base) Assumptions for Disruption Economic Cost Estimates

Parameter	Plummer et al. (1982)	Broadman and Hogan (1986, 1988)	Huntington (1993)	NES Oil Externality Draft (1990)	Miscellaneous
Disruption Probability	20% annual probability of 3 MMBD loss, 10% annual probability of loss of 10 MMBD[1] (steady state)[2]	13% annual probability of 1 MMBD, 3.5% probability of 3 MMBD, 0.5% probability of 6 MMBD loss of import supply to U.S.[3]	10% annual probability of $30/BBL price shock (1982$)	Base: 1% probability of > 15% loss (8.1 MMBD), 7.5% probability of > 5% loss (2.7 MMBD). Alts: probabilities are 1.5%, 8.5% respect.	
Disruption Duration	1 year initial, with ≤ 50% probability of continuation	1 year	1 year	6 months	
SPR Policy	Optimal stock management and size for premium estimate	Rule: 1/2 of shortfall or 1/2 of reserve	Unstated (incorporated in assumed price jump)	Cases: no use vs. full offset of shortfall (600 MMBD reserve)	
Other Disruption Offsets	None	None	None	6.9 MMBD average, foreign stock, excess capacity, fuel switching	
GDP SR Response to Price Change	Unknown	-0.05 elasticity of GDP	NA	-0.025 elasticity of GDP	
Short-run Demand and Supply Responses	SR elasticity of oil substitution = 0.04	Linear SR curves, elasticity 0.05	SR elasticity (fixed $30 price shock)	Increase w/ disruption size, .10-.22 1st quarter	
Short-run OPEC behavior	Follows price reaction function	Part of SR import supply	Completely elastic at shock price	Fixed production (elasticity 0.0)	

1 Disruptions are proportionally shared according to consumption levels regardless of the size of disruption.

2 Base Case Disruption Probability Transition Matrix

Disruption, t		Disruption, year t+1	
	Normal	3 mmbd	10 mmbd
Normal	0.85	0.10	0.05
3 mmbd	0.425	0.05	0.075
10 mmbd	0.20	0.30	0.50
LR Stationary	0.70	0.20	0.10

3 Broadman and Hogan consider four cases of disruption probabilities (World View 2 is base): Annual Probabilities: One Year Interruption in Import Supply to U.S.

World View	1 MMBD	3 MMBD	6 MMBD
W0	0.0%	0.0%	0.0%
W1	6.7%	1.0%	0.5%
W2	13%	3.5%	0.5%
W3	26%	6.7%	2.2%

Table 5.4: Economic Cost Components: Estimates ($/BBL Imports, Unless Otherwise Stated, 1993$)

Component	Plummer et al., (1982)	Broadman and Hogan (1986, 1988)	Huntington (1993)	NES Draft (1990)	Miscellaneous
Monopsony Effect (Normal Market Increased Prices & Excess Wealth Transfer)	$5.20-$10.40	a. $1.50 b. $5.00 c. $2.70	a. $5.70- $13.20 b. $9.10		EMF-6, w/ different OPEC assumption.[1] U.S.: $10.00-$23.00 Joint:$31.00-$68.00 Walls: < $1.60
LR Social Surplus Loss	$0.00				
LR Potential GNP Loss	$0.00				
LR Balance of Payments Costs		a. $0.91 b. $0.89 c. $1.96			
LR Inflationary Costs		a. $1.90 b. $1.30 c. $2.00			
Cost of Policy: SPR			a. $0.0 b. $0.0	$0.0 MC $0.66/BBL Consumed	Hall: $1.10-$1.70 MC
Military and National Security Costs			a. $0.0 b. $0.0	$0.00 MC $1.90/BBL Consumed AC	Hall: $10.90 MC
Noncompetitive Market Subtotal	$5.20-$10.40	a. $4.30 b. $7.20 c. $6.70	a. $5.70- $13.20 b. $9.10		EMF-6 U.S.: $10.00-$23.00
SR Social Surplus Loss in Disruption	$0.00			$0.00	
Increased Excess Wealth Transfer During Disruption	$15.60-$38.10		a. $3.80 b. $3.80	a. $0.20-$0.60 b. $0.60-$1.70	
Macroeconomic Losses During Disruptions (Adjustment Costs)	$5.20-$6.90 (assuming consumption reduced with imports, $0 otherwise)				

Component	Plummer et al., (1982)	Broadman and Hogan (1986, 1988)	Huntington (1993)	NES Draft (1990)	Miscellaneous
Disruption/ Security Subtotal	$20.80-$45.00	a. $10.20 b. $9.30 c. $0.00	a. $3.80 b. $3.80	a. $0.20-0.60 b. $0.60-$1.70	
TOTAL ECONOMIC	$26.00-$55.40	a. $14.50 b. $16.50 c. $6.70	a. $9.50-$17 b. $12.90	a. $0.20-0.60 b. $0.60-$1.70	

[1] EMF-6 Monopsony Premium Estimates (1993$)

Model	Gately	IEES	IPE	Salant/ ICF	ETA/ Macro	WOIL	Kennedy	OIL-TANK	OIL-MAR
Joint:	$31	$50	$31	$48	$68	$36	$52	$47	$68
U.S.:	$10	$16	$10	$14	$23	$12	$14	$14	$23
OPEC assum.	target capital utility	target capital utility	target capital utility	inter-temporal optimize	price-reaction function	target capital utility	fixed production market prices	target capital utility	target capital utility

Notes:

Plummer et al (1982)
Cases vary mostly by disruption frequency. Variation in non-disruption costs due to alternative buying power assumptions.

Broadman and Hogan (1986, 1988)
- a. High price
- b. Low price
- c. Secure imports

Huntington (1993)
- a. Low estimate - high estimate
- b. 6-Model Average

NES Draft (1990)
- a. Midcase disruption probability and excess capacity
- b. High disruption probability and low excess capacity

For both cases (a) and (b), the low end of range corresponds to immediate SPR use and the high end of range corresponds to no SPR use.

5.2 Updated Estimates of Broadman and Hogan's Oil Import Premium

This section provides new estimates of the economic oil import premium, based on updated parameters, and for a variety of assumptions. First we review the critical assumptions which must be made for estimation. Estimates are then provided, broken down by each premium component, for assumptions spanning the range of views offered by energy analysts. The estimates are based on current oil market prices and quantities, and use estimates of long-run oil market responsiveness derived from the Department of Energy's Oil Market Simulation Model, 1994 version (OMS94). The resulting economic portion of the oil import premium varies between $0 and $10, depending on the view adopted. It is not necessary to conclude from this wide variation that we know nothing about the level of the oil import premium. Rather we may conclude that we know a fair amount about how different premium estimates arise, and what confluence of events and conditions is required for the premium to be large or small.

The estimation method is consistent with most recent approaches [e.g., Broadman and Hogan (1988), DOE NES Oil Externalities Subgroup (1990), Walls (1990), Huntington (1993)] in its focus on the marginal value of import reduction at current and optimal import levels, and in its division of the premium into long-run noncompetitive market costs and expected disruption costs. Like these approaches, the dynamic behavior of the oil market is simplified by using long-run and short-run price-responses (elasticities) for major supply and demand regions, with linear approximations of short-run behavior. A range of OPEC supply responses are considered. In the interest of completeness and consistency, the accounting framework follows Broadman and Hogan (1988), since that study estimated the most inclusive set of potential marginal cost components.[29] The approach accounts for tradeoffs among components and for potentially important second-order effects of long-term imports reduction. Adopting this comprehensive approach does not predetermine the answer, however, because the framework admits the possibility that many components are of limited importance, given suitable assumptions.

5.2.1 Important Uncertainties

The many previous efforts at estimating the oil import premium indicate which conditions and parameters are most important. Based on the above review of components and approaches, the following are known to be among the most important determinants of the estimated premium size.

- OPEC supply behavior
- Demand/policy behavior of other importers
- Fraction of long-run inflation accommodated (versus eliminated through macro policy)
- Import payments recycling rate
- Disruption probabilities
- Disruption offsets (gross versus net shortfall distinction)
- SPR policy (size and drawdown during disruptions)
- Short-run net-import demand elasticities
- Degree of disruption anticipation/expectation
- Macroeconomic policy during disruptions

[29] We are grateful to Professor William Hogan for providing work files which clarified his approach.

5.2.2 Treatment of Disruption Probabilities

The disruption components of the oil premium (increased imports costs and GNP adjustment costs) are each weighted by the probabilities of disruption. An inclusive range of disruption probabilities would include the possibility that there are *no* net disruptions, that is, no disruptions large enough to exceed the available excess production capacity and U.S. and foreign strategic reserve drawdown capability. This result closely approximates the mid-case assumptions used in the DOE/Interagency 1990 SPR Size Study, as well as the revised disruption probability and offset assumptions developed for the DOE/EIA modeling work in this study, *if* all disruption offsets are available. Under these assumptions there is little probability (0.3%, or 2% excluding the SPR draw), of a disruption exceeding the full range of offsets and the expected (probability-weighted) price increase due to shocks is nearly zero ($0.04 in 1995). In contrast, many previous studies of the premium have considered expected disruption price increases of $2 to $3/BBL (e.g. Hogan and Broadman 1988, Huntington 1993).

The approach to disruptions adopted by the 1990 DOE SPR Size Study restricts concern to net *quantity* shortfalls in the oil market. That approach applies multiple offsets (e.g. excess production capacity, fuel switching, strategic stock draws) to gross supply losses in a manner that completely eliminates any price rise for most disruptions. The estimated frequency of gross quantity shortfalls is loosely based on historical observation. An alternative approach, used in some of the cases examined here, would recognize that only a fraction of these offsets may be applied, and even then only after price rises high enough to provide a strong signal. Historically, five events since 1973 have caused substantial price rises (greater than either $4/BBL or 20% of prevailing price), for at least a few months.[30]

The DOE90 study applies large offsets to the gross disruption sizes considered, and as a result there is a very low probability of price shocks (compared to history or to other oil disruption analyses). In general, the DOE90 net disruption probabilities are closely approximated by zero in the tables. However, since most of the assumed offsets are from excess production capacity in Persian Gulf region, it maybe optimistic to assume that they are fully and promptly available during disruption. The "medium" and "high" net disruption probability cases in the Tables roughly correspond to the DOE90 *gross* disruption probabilities with reduced offsets as shown by Table 5.5.

For the medium and high disruption probability cases reported here, the expected price increase due to shocks is $0.67 and $1.31 respectively. As seen below, the "medium" probabilities used here for net disruption sizes substantially exceed the DOE90 study probabilities for comparably-sized disruptions net-of-offsets, but the "high" probabilities are lower than the corresponding DOE90 study probabilities if one excludes non-SPR offsets:[31]

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[30] Included are the 1973 Arab-Israeli war and embargo, the 1979 Iranian Revolution, the 1980 Iran-Iraq war, the 1988 UK Piper Alpha Platform explosion, and the 1990 Persian Gulf war.

[31] DOE 90 study probabilities are given as continuous Weibull distributions. These were converted to discrete disruption size probabilities by constructing bins around the stated values with conditional expected value approximately equal to the bin value.

Table 5.5 Comparison of Annual Disruption Probabilities for Varying Non-SPR Offset Assumptions

	Disruption Size		
	1 MMBD	3 MMBD	6 MMBD
DOE90 Midcase, Net Disruptions (full offsets)	0.8%	0.6%	0.15%
This study, Medium Case, Net Disruptions	6.7%	1.0%	0.5%
This study, High Case, Net Disruptions	13%	3.5%	0.5%
DOE90 Midcase, Gross Disruptions (no offsets)	38%	24%	6%

5.2.3 Premium Components Estimated, and the Direct and Indirect Effects Included

The premium components estimated here include the major categories discussed in Sections 3 and 4. Each premium component corresponds to the marginal effect of changing long-run (base) imports on one cost component. Hence some premia necessarily involve indirect or second-order effects. An important lesson from the numerical results is that such effects, while commonly omitted, are not necessarily insignificant. Included are[32]:

- Noncompetitive Market Components

  - Recoverable Cartel Rents (Monopsony Effect)
    The marginal effect of long-run imports reduction on the undisrupted period price, times the level of imports [standard approach (see 3.4.2)].
  - Balance of Payments Cost
    Effect the incremental trade deficit due to oil imports on exchange rate and cost of other imports. Depends on the recycling rate [see Equation (7)].
  - Long-run Inflation Costs
    The marginal costs of controlling incremental inflation due to imports, given rising real imports price. Depends on the marginal effect of imports on oil price, the rate of price growth, and the consumption of oil and close substitutes. Proportional to the fraction of inflation unaccommodated i.e., eliminated by macro policy [based on Broadman and Hogan (1988)].

- Disruption Cost Components
  (All disruption components are *expected* marginal costs, hence are proportional to the probability of disruption)

  - Disruption Social Surplus Loss
    The marginal change in disrupted period social surplus "triangles" due to:
    a. the effect of base imports on disruption price change ΔP_i; and

[32] Note: Omitted from the current estimates is the marginal change in GNP adjustment loss which might follow from the effect of the base import level on the base consumption level, since consumption is held constant.

b. the effect of base imports on demand response during disruption, Δq_i.

- Disruption Increased Imports Costs

  The marginal change in the increased costs of imports during a disruption due to:

  a. the effect of base imports level q_i on disruption imports level $q_i+\Delta q_i$, altering loss exposure for any given disruption price change ΔP_i; and

  b. the effect of base imports on disruption price change ΔP_i, altering disruption excess wealth transfer for any given disrupted imports level $q_i+\Delta q_i$.

- Disruption GDP Adjustment Losses

  The marginal change in GDP adjustment losses (which are a function of oil consumption, base GDP, and disruption relative price change) due to:

  a. the effect of base imports level on the disruption price change ΔP_i; and

  b. the effect of base imports level on base price P_i, and thereby the relative disruption price change $\Delta P_i/P_i$.

5.2.4 Updating Original Broadman and Hogan Estimates for 1985 With 1994 Conditions

As reported in Table 5.4, the mid-case estimate of the total economic premium by Broadman and Hogan was $14.50 per barrel (1993$), based on 1985 conditions. We might expect the premium to be much lower now, given lower oil prices and reduced U.S. share in the world oil market. For the purposes of comparison, the Broadman and Hogan estimates were re-generated, with parameters altered to match 1994 oil market conditions (See Table 5.5). Note that for this initial comparison, the disruption probabilities were not "updated" since they remain uncertain, moreover the goal is to examine the effect of changing base-market conditions on the import premium. Looking at the entries in Table 5.5, we see that a number of market developments since 1985 are expected to lower the import premium. The base oil price is lower, oil is a smaller share of total expenditures, and less important in the U.S. total trade flows. U.S. imports and demand are a somewhat smaller share of world oil trade or demand (from 36 percent to 31 percent), making import reduction less effective for reducing the size of a potential disruption (shortfall) to the United States. The price-responsiveness of foreign net imports supply to the U.S. (from OMS94 implicit elasticities) is greater, so the expected world price change per unit imports change is lower. The smaller expenditure share of oil indicates smaller GNP adjustment losses during disruptions, and the SPR is larger.

The principal development contributing toward a larger import premium is the substantially higher 1994 import level. We see from Table 5.7 that all components of the premium are reduced except those relating to the monopsony wedge or excess wealth transfer during normal and disrupted periods. The undisrupted-market monopsony premium is slightly larger than in the Broadman-Hogan estimate for 1985. With the optimal premium lower overall ($9.91 compared to $14.51), there will be a smaller import reduction at the new optimal level, therefore leaving the monopsony premium relatively larger. Using the updated Broadman-Hogan base assumptions, the total economic import premium, at the optimal import level in 1994, is still around $10 per barrel. Note that the *base* premium ($14.60 in 1994, $23 in 1985), evaluated at the current level of imports rather than the optimal level, will always be higher than the optimal premium. It is important to bear in mind, however, that these import premium estimates are uncertain, and depend strongly on disputed assumptions. The next section explores how that $10 premium estimate can erode, if certain important assumptions are changed.

Table 5.6: Updated Oil Market and Economic Parameters of Broadman and Hogan (1988) Study of 1985 versus 1994 Conditions

Assumption	Broadman and Hogan (1988) Value, 1985	Updated Comparison Value, 1994	Source/Comments
Base Oil Price (1993$/BBL)	$35.52	$16.91	Annual Energy Outlook 1994
Rate of Growth in Real Oil Price	3%	3.4%	Annual Energy Outlook 1994, long-run growth rate, Base price path
Base U.S. Oil Imports	6.0 MMBD	9.0 MMBD	Annual Energy Outlook 1994
U.S. Exports (93$ Billion)	$299	$464	Int'l Financial Statistics, 1994
Non-Oil imports (1993$ Billion)	$375	$498	Int'l Financial Statistics, 1994
Reduction in Disruption Size per BBL Reduction in Base Imports (BBL/BBL)	36%	31%	Based on U.S. share of world demand (U.S. share of world imports is comparable)
Slope of Long-run Imports Supply Curve ($/BBL per MMBD Imports Change)	$0.50	$0.37	Based on OMS94 regional elasticities, and OPEC price elasticity of 1.0 (see Table 3.5)
U.S. Long-run Elasticity of Demand	-0.5	-0.19	OMS94 implied elasticities
U.S. Long-run Elasticity of Supply	0.50	0.60	OMS94 Implied Elasticities
GDP ($ Billion)	$5300	$6381	Annual Energy Review 1993 p. 361
Oil Expenditure Share of GDP	3.5%	1.74%	Calculation from above (combined oil & gas shares roughly in same ratio)
Elasticity of GNP with Respect to Disruption Price Rise (GNP Adjustment Cost Parameter)	0.05	0.025	Consistent with a reduction in the oil expenditure share of GNP from to 3.448% to 1.76%, also consistent with DOE 1990 SPR Size Study Mid-case.
SPR Size (Million BBL)	500	600	Approximate current size
Disruption Probabilities	See Table 5.3	Unchanged	Defer for later sensitivity analysis

Table 5.7: Comparison of Premium Estimates 1985 vs. 1994, With Updated Market Parameters (Optimal Premium, $/BBL Imports, 1993$)

Component	1985 Broadman and Hogan est. (1986, 1988)	1994 Simple Updated Estimate
Recoverable Cartel Rent (Monopsony Effect)	$1.46	$1.85
LR Balance of Payments Costs	$0.91	$0.32
LR Inflationary Costs	$1.90	$0.97
Noncompetitive Market Subtotal	$4.27	$3.14
SR Social Surplus Loss in Disruption	$0.56	$0.22
Increased Import Costs During Disruption	$2.95	$2.96
Macroeconomic Adjusted Losses During Disruptions	$6.73	$3.60
Disruption/Security Subtotal	$10.24	$6.77
TOTAL ECONOMIC	$14.51	$9.91

Notes: See Table 5.5. Disruption probabilities unchanged in updated estimate.
LR - Long-Run, SR - Short-Run

5.2.5 Sensitivity of Import Premium Estimate to Alternative Oil Market Conditions

The import premium estimate of $10/BBL was constructed using updated assumptions from Broadman and Hogan (1988). While inclusive, this does not constitute the highest estimate consistent with prevailing conditions and the range of plausible assumptions currently offered. The disruption probabilities, while higher than those used in recent DOE studies [e.g., DOE SPR Size Study (1990), DOE NES Oil Externalities Draft (1990)], imply a lower expected price increase than those used by Huntington (1993), for example, or many earlier studies (see Table 5.7). The estimated premium would be up to 50 percent higher if it were assumed that OPEC members will defend their output quotas (were completely inelastic), and allow price to fall further. It would also be greater if one assumed that other OECD importers acted jointly with the U.S., reducing their imports in the same proportion.[33]

[33] Those components proportional to the reduction in world demand would be about 2-3 times greater, at the base import level. However, other components more dependent on the U.S. level of imports or consumption (e.g., balance of payments costs due to worsening terms of trade) would be less affected. Furthermore, the *optimal* premium (premium at the optimal level of imports) would be reduced by less than the base level premium.

Table 5.8: Comparing Expected Disruption Price Increases

Study	Expected Price Increase
Huntington (1993)	$3.00/BBL
Broadman and Hogan (1988), applied to 1994	$1.81/BBL base, $1.66/BBL at optimal imports
DOE SPR Size Study (1990), Mid-Case	$0.04 - $0.13[34], 1994 to 2010

On the other hand, substantially lower premium estimates are obtained when one questions the key assumptions in turn. To highlight the reasons why oil import premium estimates vary so widely, we can show how the methodology used above admits estimates ranging from $10/BBL to near zero, as assumptions are varied. The selection of particular assumptions is left to the reader as a subjective and empirical question beyond the scope of this paper.

Nine cases were considered, starting from the updated Broadman and Hogan estimates. The changes considered in each case also apply to the successive cases (i.e., are cumulative). The results for each premium component are reported in Table 5.9.[35]

Case 1: OPEC Supply Moderately Price Responsive

Here OPEC supply elasticity is 1.0, and the resulting elasticity of net import supply to the United States is about 5. This implies a moderate degree of monopsony power for the United States. The direct monopsony premium at the optimal import level is $1.85, substantially lower than many previous estimates of that premium component alone. For a given elasticity of imports supply, the base monopsony premium is proportional to price [see Section 3, Equation (8)]. The constant of proportionality is one over the elasticity. Hence for a base oil price of $16.90, the base monopsony premium in this case is about $3.30. When interactions with the other premium components are accounted, and the optimal import level determined, the monopsony premium estimate is substantially smaller ($1.85). However, this case emphasizes the many other potential components of the oil import premium can have non-trivial values, depending on important details of how the oil market and economic policy work. These components are often omitted.

Case 2: Highly Elastic OPEC Supply

OPEC suppliers may defend price, by cutting back production to offset most of the import reduction (OPEC elasticity equals 5.0). Here the elasticity of net import supply to the United States is about 18, comparable to the range considered by Walls (1990). The base monopsony premium is $0.96, comparable to Walls' estimate of under $1, and the optimal level is $0.54. The inflationary cost component, which also depends, in part, on the responsiveness of the base oil price to marginal import changes is a bit lower. It is noteworthy that while the long-run economic premium components decline, some of the disruption premium components are a bit

[34] This study assumed a one percent annual probability of a disruption greater than or equal to 15 percent of world demand (8.1 MMBD), and includes offset of 8.25 plus an SPR annual draw capability of 3.3 MMBD. A disruption large enough to exceed all offsets (and thereby increase prices) has a probability of 0.005.

[35] Note that these estimate are by no means precise, and the reporting of two decimal places is done only to indicate some of the smaller relative changes between components and cases.

higher than in Case 1. This is an example of the interactions among the optimal premium component estimates, which are often compensating [Broadman and Hogan (1988)]. In this case, since import reductions are less effective in reducing price, at the optimal level the undisrupted world oil price and the import level are somewhat higher. Accordingly, the optimal disruption premium is slightly higher while the normal market economic premium is lower.

Case 3: Low Balance of Payments/Term of Trade Costs

If payments for oil imports are quickly and fully "recycled" by the subsequent foreign purchase of U.S. goods (either by oil exporters or others), or if there are offsetting capital account adjustments, then the terms of trade losses induced by the imbalance of payments are minimized. In this case we assume that the proportion of oil import payments quickly recycled is 75 percent, rather than 25 percent. The balance of payments premium, already modest, decreases in direct proportion to the recycling rate.

Case 4: Low Inflationary Costs

The long-run inflationary costs depend on the fraction of oil-induced inflation left unaccommodated by macroeconomic policy. If *all* of the inflationary effect of an anticipated long-term oil price growth is accommodated (100 percent rather than 70 percent is left unchecked), then output losses are avoided, and this premium term becomes zero. The same is true if one takes the view that oil pries are not a major source of long-term inflation. As in other cases, the total premium declines by less than the long-run inflationary premium term, due to interactions.

Case 5: Import Levels Have No Marginal Effect on Disruption Sizes

Changes in import levels could alter the effective size of disruptions subsequently faced by the United States [Broadman and Hogan (1988)]. Possible mechanisms include the creation of idle production capacity, the alteration of sharing rights under the IEA International Energy Program, reduced oil trade flows subject to interruption (accidental or intentional) and the reduction in output levels from potentially disrupted sources. Previous cases considered the possibility that import supply net disruption sizes decrease with marginal reductions in normal market imports. The marginal reduction rate assumed was 31 percent, roughly matching both U.S. imports as a share of world oil trade, and U.S. demand as a share of world oil demand. In this case the marginal reduction in disruption size per barrel imports reduction is five percent. With minimal effect of imports on disruption size, the disruption premium components are substantially reduced. Note that none of the estimates produced for Table 5.9 assume any effect of imports on the likelihood of disruptions (sometimes called the deterrence effect).

Case 6: Private Expectations Internalize Disruption Price Increase

Oil prices represent the marginal cost of oil to private consumers. The price of oil in an undisrupted market is universally agreed to be borne by private agents, and therefore fully internalized. Oil consumers may also anticipate some of the disruption-related price increases when making oil-related decisions. Accordingly, some fraction of the expected price increase due to disruptions is internalized, depending on the foresightedness and expectations of private agents. This portion of the disruption cost should be excluded then from the social import premium. It is assumed that the share of disruption price increase internalized is 75 percent, rather than the more common assumption of zero percent. If so, the total optimal premium decreases by $1.25, that is, somewhat less than 75 percent of the $2.00 expected price increase in Case 5.

Case 7: Zero GDP Adjustment Costs During Disruption

Some analysts assert the connection between oil prices and economic activity is not that strong, provided effective macroeconomic policy is used to limit potential transitional losses of GDP due to oil price shocks. This possibility is modeled with a GDP elasticity with respect to disruption price of zero. The $1.80 macroeconomic adjustment loss premium component from Case 6 is eliminated, and the total premium declines by $1.20. Note that the hypothesized existence of the GDP adjustment loss implies an income-induced contraction of demand during a disruption. Conversely, assuming that the GDP loss does not occur eliminates the anticipated income shift of demand, effectively decreasing the expected price elasticity of demand during disruptions. Hence the expected price shock size grows, from $2 to $2.40. This also explains the increase in expected disruption costs.

Case 8: More Stable World with Lower Disruption Probabilities

The disruption probabilities used by Broadman and Hogan are higher than those used in some recent studies, although lower than others (see Tables 5.3 and 5.7). In this case the disruption risk is halved, with the expected oil price increase at base import levels declining from $2.40 to $1.20. The disruption premium components are likewise halved.

Case 9: Minimal Oil Exporter Market Power and Minimal U.S. Economy Market Failure

This case is modeled with a zero probability of any net shortfall in supply after the application of offsets and the SPR. That is, there is a zero probability of price shocks from any source. Equivalently, the ruling assumptions could be that the adverse economic consequences of paying more for oil during an oil supply disruption would be 100 percent anticipated and that the U.S. economy will smoothly and efficiently adjust to the oil price shock. There also is no long-term premium due to the exercise of seller market power, and thus no motivation for U.S. intervention. In this case, all of the premium components reduce to zero, except for a minor balance of payments term which suggests some cost associated with oil's part of the continuing trade deficit.

Table 5.9: Range of Oil Import Premium Estimates (Optimal Premium for 1994, 1993 U.S. Dollars Per Barrel)

Case:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Assumptions / **Components**	1994 Simple Update of Broadman-Hogan Estimate	Highly Elastic Supply, Low Monop-sony Power	Low Balance of Payments Costs, Fast Recycling	Less Inflationary Accommo-dation	Minimal Effect of Base Imports on Disruption Size	Private Expecta-tions Internalize Disruption Price Increase	Zero Macro-economic Adjustment Costs	More Stable World (disruption probabilities halved)	Perfectly Stable World, No monopsony power
Recoverable Cartel Rent	$1.85	$0.54	$0.55	$0.58	$0.72	$0.79	$0.85	$0.87	$0.00
Long-run Balance of Payments Costs	$0.32	$0.35	$0.12	$0.12	$0.16	$0.18	$0.19	$0.20	$0.21
Long-run Inflationary Costs	$0.97	$0.77	$0.77	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Long-run Economic (Normal Market) Subtotal	$3.14	$1.66	$1.44	$0.70	$0.88	$0.96	$1.04	$1.07	$0.21
Short-run GNP Loss in Disruption	$0.22	$0.22	$0.22	$0.21	$0.00	$0.00	$0.06	$0.03	$0.00
Increased Import Costs During Disruption	$2.96	$3.03	$3.05	$3.14	$1.89	$0.35	$0.86	$0.43	$0.00
Macroeconomic Adjustment Losses During Disruptions	$3.60	$3.64	$3.66	$3.74	$1.71	$1.83	$0.00	$0.00	$0.00
Disruption/ Security Subtotal	$6.77	$6.88	$6.93	$7.09	$3.60	$2.18	$0.92	$0.46	$0.00
TOTAL ECONOMIC ESTIMATE	**$9.91**	**$8.54**	**$8.37**	**$7.79**	**$4.49**	**$3.15**	**$1.97**	**$1.53**	**$0.21**
Notes	Moderate monopsony power, (OPEC elasticity = 1)	OPEC maintains price by offsetting imp. reduction (elasticity= 5)	Rapid recycling of foreign oil revenue (75 percent versus 25 percent)	U.S. macro policy does not trade output for inflation (accommo-dation 100 percent versus 70 percent)	$d\epsilon/dq_i = .05$ rather than .31 (U.S. import share), ϵ is disruption size to U.S.	Share of disruption price increase internalized 75 percent versus 0 percent	GDP elasticity with respect to oil price = 0 (versus 0.025)	Disruption probability halved (expected price increase $1.20 versus $2.40)	Zero probability of net disruption (after offsets and SPR), OPEC supply perfectly elastic.

Disruption probabilities from Broadman & Hogan (1988). See Table 5.5.

5.3 Estimation of the Most Robust Economic Components of the Oil Import Premium

The estimates of the oil import premium provided here are based on current oil market prices and quantities, and use estimates of long-run oil market responsiveness derived from the Department of Energy's(DOE) Oil Market Simulation Model, 1994 version (OMS94). Calculations are made with the Broadman and Hogan model. The estimation method used is consistent with most recent approaches in that it does not include environmental components. Instead, the method focuses on the marginal value of import reduction at current and economically efficient import levels considering only disruption costs and long-run economic costs. The approach used here accounts for trade-offs among components and for potentially important second-order effects of long-term reduction of imports.

The calculations presented in this subsection eliminate the controversial balance of payments and inflation costs because of the weakness of their theoretical foundations. Social surplus losses during disruptions are small in any event, and we omit those possible costs to avoid distraction from the three most important and robust cost categories—avoidable cartel rent, increased import costs during disruptions, and macroeconomic adjustment costs during disruptions.

Tables 5.10 through 5.13 reveal the sensitivity of the three principal, potential economic externalities of oil imports at the margin to important oil market conditions. For each component, a numerical measure of the total cost is identified, and the marginal variation of that cost with respect to imports is calculated and reported. This avoids attributing any costs which do not vary at the margin with imports. Tables 5.10 through 5.12 report on each of the three components individually, while Table 5.13 aggregates these costs. In each of the first three of these four tables, the reported costs are calculated under the condition that the costs in the other two categories are zero. When these costs are aggregated in the final table, the values reported are calculated simultaneously, which tends to reduce slightly each cost category.[36]

Cartel Rents

Table 5.10 describes the sensitivity of external costs from marginal cartel rents to the elasticity of OPEC response. Rather than attempt a dynamic model of OPEC supply response behavior, the long-run response to a U.S. import reduction is represented with a simple OPEC response elasticity parameter.[37] The range of that parameter is from completely inelastic (a vertical cost--or supply--curve) to completely elastic OPEC oil supply.

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[36] This is because the marginal costs are calculated at the efficient level of imports, which decreases somewhat as more cost categories are included.

[37] Strictly speaking, a cartelized or monopolistic supplier will not have a well-defined supply curve. However, when a large consumer with market power initiates a demand reduction there will be a series of actions and reactions between the consumer and the large producer. The change in the supplier's asking price which ultimately results from this interaction is summarized here with a supply elasticity.

TABLE 5.10: MARGINAL CARTEL RENTS, 1993 $/BBL

OPEC Supply Response to U.S. Import Demand Changes			
Perfectly elastic (elasticity ≈ ∞)	Highly elastic (elasticity = 5)	Moderately elastic (elasticity = 1)	Completely inelastic (elasticity = 0)
0.00	0.90	2.86	6.63

Notes: All other cost components are assumed to be zero (i.e., zero net disruption risk, or disruptions and completely anticipated and hedged, and no marginal effect on macroeconomic disruption losses). These numbers are calculated using the total elasticity of net import supply. The total elasticity of net import supply to the U.S. is calculated using the OPEC supply elasticity and long-run supply and demand elasticities for non-US non-OPEC regions derived from the EIA's OMS94 model.

Oil Import Costs During Disruptions

This component corresponds to the added cost for oil imports during a disruption. Import costs during a disruption vary at the margin with the level of imports prior to the disruption. There are two issues: given a disruption, by how much will prices rise; and how much of the increased import costs due to the price rise has been anticipated and internalized by private agents? The price rise during a quantity shock is determined by short-run demand and supply elasticities. A reasonable assumption for these elasticities is 10% of the long-run price elasticities derived from the DOE/EIA OMS94 model.[38]

Table 5.11 reports the sensitivity of oil import costs during disruptions to various market conditions. First, zero, medium, and high disruption probabilities are considered. It is possible that reducing imports will reduce the risk of disruptions, by reducing their expected size. Accordingly, the analysis next explores the effect of a zero marginal effect of imports on the risk of disruption and of a non-zero marginal effect, under the high and medium disruption probability conditions. Finally, under each characterization of the marginal effect of imports on disruption risk, the consequences of anticipation and the use of hedging opportunities by consumers are considered. Such anticipation and hedging may partially internalize the higher cost of imports during disruptions. Most studies include the whole increase in the cost of imports during a disruption in the premium estimate. Here, the fraction of the shock costs avoided by anticipation and hedging is varied from 100% to 25%. The external costs will be zero with 100% anticipation and hedging. Table 5.11 assumes that all cost components other than increased import costs during disruptions are zero: i.e., that there are no cartel rents and that labor, capital, and product markets operate smoothly enough to avoid all macroeconomic adjustment costs. In these estimates, the SPR is used fully, except for the smallest disruptions (1 MMBD), in which cases only half of the SPR is used, assuming that half is withheld to protect against the event of a large disruption.

[38] These short-run elasticities are consistent with anticipated rates of short-run supply and demand adjustment toward long-run response levels. In the DOE's OMS model, these adjustment rates average about 10% per year, depending on the region, hence the short-run elasticities are about 10% of the long-run levels. The long-run elasticities used are derived from OMS, as reported in the main report.

Macroeconomic Adjustment Costs Component

Again the analysis includes only those marginal external costs which are attributable to imports. The first mechanism by which the GNP adjustment losses may be affected by changes in imports is through possible incremental changes in net disruption size. It is represented by a parameter indicating the marginal reduction in disruption quantity per barrel of reduction in imports. This parameter is called the "marginal effect of imports on disruption size." The analysis uses values between 0 and 31%, the latter figure being the current US share of world net imports from OPEC. The second mechanism, the dampening of proportional price changes, is implemented in the short-run and long-run equilibrium calculations of the model. The analysis approximates these losses with a GNP oil-price elasticity, to which are assigned values between -0.025 and -0.06. This means that an oil price doubling will cause adjustment losses of between 2.5% and 6% of GNP. The 2.5% figure is used by the 1990 DOE/Interagency study on SPR size, and is about one-half of the value commonly used prior to that date.[39] The 6% figure is the most recent empirical result (Mory 1993).

Table 5.12 reports the effects of various conditions on the magnitude of macroeconomic adjustment costs. Again, a variety of circumstances contingent upon the probability of disruption--high, medium, or zero--are compared. Under the conditions of high and medium disruption probability, the consequences are explored, in a nested fashion, of the size of the marginal effect of imports on disruption risk (again, zero and positive) and, under those conditions, the effects of the size of the GNP elasticity with respect to oil price shocks. Table 5.12 assumes that all cost components other than macroeconomic adjustment costs are zero: i.e., that there are no cartel rents which vary with imports and that disruptions are 100% anticipated and hedged.

[39] The DOE Interagency 1990 study (T2/T3 Working Group) assumed a GNP elasticity range of -0.02 to -0.04, with a preferred value of -0.025 (page 5-1).