The Costs of U.S. Oil Dependency

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Resources for the Future
1616 P Street, NW
Washington, D.C. 20036
Telephone: 202–328–5000
Fax: 202–939–3460
Internet: http://www.rff.org

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Abstract

This paper first describes trends and future predictions of factors that determine U.S. dependence on oil and oil imports. We then review evidence on the oil premium, that is, the extent to which the costs to the United States as a whole from extra oil consumption may exceed the private costs to individual oil users. The premium has two main components: one reflects the risk of macroeconomic disruptions from oil price shocks, while the other stems from U.S. market power in the world oil market. Our best assessment of the oil premium is $5/barrel (equivalent to 12 cents per gallon of gasoline), which would warrant a broad, though moderately scaled, tax on all uses of oil.

Key Words: energy security; oil imports; oil premium; macroeconomic disruptions

JEL Classification Numbers: Q43; Q41; Q38

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1. Introduction

Energy security may broadly be described as a state of affairs characterized by conditions and policies that safeguard the health of the U.S. economy against circumstances threatening significant short- or long-term increases in energy costs. It is a concept with many dimensions, only one of which—the problem of dependence on a world oil market characterized by substantial price volatility and exercise of market power—will be addressed in this paper.[1] Even the energy security aspects of oil dependence are numerous: some are geopolitical (e.g., efforts to promote the stability of oil-exporting regimes), while others revolve around geological or technological issues (e.g., the payoff from R&D investments to expand domestic liquid fuel reserves). However, the topic addressed here—the economic costs of U.S. oil consumption and import dependence—occupies a central place in energy security policy analysis and debate. The exposition proceeds as follows.

Section 2 sets the scene with a brief statistical background, including trends in U.S. petroleum consumption, imports and where they come from, oil prices, the energy intensity of GDP, and the world distribution of known oil reserves. We also discuss the potential power of OPEC to manipulate world oil prices, projected trends in U.S. oil dependency, the effect of oil

* Ian Parry (parry@rff.org) and Joel Darmstadter (darmstadter@rff.org) are both Senior Fellows at Resources for the Future. This paper was prepared for the National Commission on Energy Policy. We are grateful to Drew Kodjak for very helpful comments and suggestions and to Barbora Jemelkova for research assistance.

[1] Other dimensions include dangers to the country's energy infrastructure (transmission lines, refineries, electric power stations, pipelines, terminal facilities, etc.), safety concerns over civilian nuclear power, and disruptions in liquefied natural gas shipping, a growing factor augmenting the nation's natural gas supplies.

prices on aggregate economic activity, and the potential role of the Strategic Petroleum Reserve in mitigating against price shocks.

Section 3 discusses the components of the oil premium and recent quantitative assessments of them. The premium reflects the extent to which the costs to the United States from an extra barrel of petroleum consumption exceeds the private costs paid by oil users; it tells us how much policy intervention to reduce oil dependency is warranted on economic grounds through, for example, energy conservation measures. The premium has two main components, one reflecting U.S. monopsony power in the world oil market and ability to lower oil prices by reducing imports. The other reflects disruption costs from potential future oil-price shocks including temporary higher oil payments to overseas suppliers and a range of adjustment costs throughout the economy as industries respond to higher energy prices. Both monopsony and disruption components are difficult to pin down accurately, as a number of factors are uncertain, such as how OPEC would respond to a cut in U.S. oil imports, the likelihood of future price shocks, and the extent to which the private sector takes into account the risk of price shocks.

Estimates of the oil premium have fallen over time as the oil intensity of GDP has declined, price volatility and oil-market disruptions are less pronounced than 20 years ago, and the private sector can now respond more flexibly to shocks. Recent estimates put the total premium at between around $0 and $14/barrel, equivalent to between 0 and 30 cents/gallon of gasoline; our best assessment is that the premium is around $5/barrel. Whether the premium will increase or decrease in the future is unclear: the share of oil in U.S. GDP will continue to decline while the imported share of U.S. oil petroleum will continue to rise. One caveat is that studies of the oil premium could be biased downwards as they do not account for certain geopolitical factors that are not easily quantified, such as the risk of oil-supply sabotage by terrorists or the takeover of Saudi Arabia and other oil-rich nations by extremist governments willing to sacrifice oil revenues to inflict economic damage on the United States.

A final section briefly comments on some policy implications.

2. Background

2.1 Basic Oil Statistics

The United States consumes almost 20 million barrels of petroleum per day (MBD), or 7.2 billion barrels annually. Easily the most important use is the production of gasoline for motor vehicles, which accounts for 45% of petroleum products; distillate fuel oil (e.g. diesel fuel) accounts for 19%, liquefied petroleum gases 10%, aviation fuel 8%, and a variety of other uses combined 18% (see Figure 1).

U.S. demand for petroleum fell from an initial peak of 18.8 MBD in 1978 to 15.2 MBD in 1983 following the second major oil price shock; since then it has grown steadily with the general expansion of the economy, increased demand for travel, and so on, and is now around 20 MBD (Figure 2). However the petroleum intensity of GDP has almost halved in the last 30 years, down from 1.5 barrels per thousand dollars of (real) GDP to 0.8 barrels in 2000 (Figure 2), with improved energy efficiency and a shift away from oil in the electricity sector.[2] Declining oil intensity means that the effect of oil price changes on the economy is significantly less—in relative terms—than in the 1970s.

The United States currently imports 11.6 million barrels of petroleum per day, or 59% of its consumption, compared with 23% in 1970 (Figure 3). There was a sharp fall in the oil-import fraction from the late 1970s to the mid 1980s as high prices encouraged an expansion of high-cost domestic production; however domestic production has been steadily losing ground to low-cost foreign suppliers since then as oil prices have fallen. Forty-seven percent of U.S. oil imports currently come from OPEC countries, and about half of OPEC imports come from the Persian Gulf, with Saudi Arabia being the dominant exporter. Canada and Mexico combined supply about half of non-OPEC imports to the United States. The United States is easily the world's largest oil consumer, accounting for 25.4% of world consumption (Table 1).

OPEC countries produce around 42% of world oil, and of these supplies 68% come from the Persian Gulf (Table 2). Saudi Arabia produced 8.0 MBD in 2001, while Iran, Iraq, Kuwait, and United Arab Emirates each produced between 2.0 and 3.7 MBD. Venezuela and Nigeria are

[2] For example, average fuel economy of all on-road vehicles has increased by 40% over the last three decades, though the growth has stalled in recent years with the increasing market share of sport utility vehicles, pick-up trucks, and minivans (see www.fhwa.dot.gov/ohim/onh00/line9.htm).

the two largest non-Gulf OPEC producers. The major non-OPEC producers include Russia (7.1 MBD in 2001), United States (5.9), China (3.3), Norway (3.2), and Mexico (3.1). It is estimated that the Persian Gulf region has around two-thirds of the world's known oil reserves (that would be profitable at current prices), while the United States has only 2% of reserves (Table 2).[3]

2.2 Previous Oil-Price Shocks and Trends

The two most dramatic oil-price shocks both doubled prices—from around $12 per barrel to $25 during the Arab-Israeli war in late 1973, and up to $50 per barrel in 1980, following reduced production during the Iran-Iraq war (figures in 1996 dollars). Prices fell rapidly shortly after that, and since the mid-1980s have fluctuated between $12 and $25 per barrel (Figure 4).[4]

The main cause of the two big price shocks was supply disruptions by Persian Gulf countries.[5] Middle East production was cut back by 4–5 MBD in each case, which then represented a world oil-supply reduction of nearly 10%. In the short run (up to a year), the demand for oil is very insensitive to price: a typical estimate for the short-run price elasticity is –0.1 (e.g., Huntington 1991, 1993). This implies that a 10% oil-supply reduction would initially double the world oil price.

After the oil-price shocks, OPEC members restrained production through negotiated country quotas in succeeding years in an attempt to keep prices at the new higher levels: for example, OPEC production fell from 30.6 MBD in 1979 to 16.2 MBD in 1985 (Figure 5). Nonetheless, prices still fell steadily; over time higher prices encouraged a reduction in demand through energy conservation, fuel switching, and other means, and oil production increased in non-OPEC countries as previously uneconomic wells became profitable and increased exploratory activity brought previously unknown reserves online.

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[3] Known economic reserves grow over time with exploration and improved technology for extracting it. Nonetheless the U.S. geological survey's world petroleum assessment puts ultimate world resources at about double currently known reserves, with 55% located in the Persian Gulf region and 5% in the United States.

[4] All these figures refer to oil prices averaged over a year. The variation in spot prices is obviously more dramatic; for example prices reached $40 per barrel in September 1990, prior to the first Gulf war.

[5] Another contributory factor may have been excessive oil inventory buildup in 1979–80.

At the beginning and the end of the 1990s there were two further oil-price rises, though they were less pronounced than in the earlier period. In 1990 during the first Gulf war, oil output from Kuwait and Iraq fell by almost 5 MBD; however expanded production from Saudi Arabia made up much of the lost supply. And from 1998 to 2000 oil prices jumped from $12.1 to $26.4 per barrel. This resulted from OPEC expanding production just as East Asia was going into an unexpectedly sharp downturn; to correct the oil glut OPEC cut production in 1999, just as East Asian economies rebounded faster than anticipated.

Finally, a casual inspection of Figure 5 does not reveal any obvious long-run upward trend in oil prices, counter to some predictions during the 1970s that the world was running out of oil. So far at least, exploration and improvements in extraction technology have neutralized any pressure for rising prices from the depletion of oil reserves.

2.3 Market Power of OPEC

Worldwide, there are several exporting countries that are willing to produce well below their capacity in order to retain influence over prices; they include the big five Persian Gulf exporters listed in Table 2, Venezuela, and two non-OPEC countries (Mexico and Norway).[6] OPEC is a far cry from a well-coordinated group of countries agreeing on a single strategy to maximize their joint profits from oil exports. Nonetheless, at least in theory, a number of factors facilitate their ability to manipulate prices. One is that significant supply reductions can have a dramatic immediate effect on raising oil prices and profits for oil exports, as world demand, and supply in non-OPEC countries, are highly price insensitive in the very short run. Another is that seven countries in OPEC are responsible for over 80% of its production, limiting the number of governments that must reach agreement for an effective strategy. And oil is a homogeneous product, which makes it easier to check whether member countries are sticking to agreed limitations, at least as production data becomes available on a quarterly basis.

However OPEC is hardly a unified bloc; under the Baathist regime Iraq went to war with Kuwait and Iran, and Iran has frequently differed with Saudi Arabia. And among OPEC's 11

[6] Other oil-producing countries, including the United States, run at or close to full capacity, making them price takers.

member countries there is no enduring consensus about pricing policy. In general the countries with large populations and urgent requirements for development financing tend to favor the highest possible oil prices now. But the countries with large reserves and smaller populations, particularly Saudi Arabia and Kuwait, take a longer perspective and seek to manage prices to maximize returns over a period of decades. That means holding prices down to discourage large new investments in high-cost sources by non-OPEC suppliers and major innovation on the demand side to further reduce oil dependency. The current target range in the Saudi-Kuwaiti strategy seems to be around $20–28 per barrel. In the absence of unusual emotional circumstances, such as the 1973 Arab-Israeli war, the Saudi-Kuwaiti strategy usually prevails.

On balance the evidence appears to suggest that OPEC, or at least a core group within OPEC, has acted as a monopolistic cartel in the past. Empirical studies suggest that OPEC supply behavior conforms more closely to an (imperfect) output-sharing cartel than a competitive model (e.g., Griffin 1985, Dahl and Yücel 1991, Jones 1990).[7] Furthermore, most estimates of marginal production costs for OPEC producers, or prices that would prevail in a competitive market, are well below observed prices.[8]

2.4 Projections of Future U.S. Oil Dependence

Table 3, which is based on the Energy Information Administration (EIA)'s "Reference Case," shows projections for various oil statistics over the next 25 years. These projections reflect several widely accepted trends.

The first is consistently increasing U.S. petroleum consumption from around 20 MBD in 2000 to just under 30 MBD by 2025. This is due to the anticipated expansion of the economy in general and continued growth in the demand for travel (despite increasing congestion on roads).

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[7] And the casual observation that OPEC routinely sets production quotas implies that its members believe they can manipulate market prices.

[8] Estimates of the costs of developing reserves, adjusting for depletion or scarcity rents, suggest marginal costs for Persian Gulf producers of below $2/barrel (e.g., Adelman and Shahi 1989, Dahl and Yücel 1991). And predictions of oil prices in simulated competitive markets by Energy Modeling Forum (1992) and Greene and Leiby (1993) are around $5 to $10/barrel (in year $1990).

The second trend is OPEC's steadily growing share of world oil output from around 40% today to around 50% by 2025, which reflects the large concentration of low-cost reserves among its Persian Gulf members. This is in spite of expanded supply in certain non-OPEC countries, particularly Russia.[9]

Third, a steep increase in the share of imports in U.S. oil consumption, up from 42% in 1990 to 68% (or 20 MBD) by 2025. This reflects the growing gap between rising domestic demand and stagnant domestic supply.

Fourth, however, the EIA projects a further decline in petroleum intensity of GDP, down from 4.2 Btus per $1 of GDP in 2000 to 2.8 in 2025, suggesting that the costs from a given price spike will be a smaller proportion of GDP.[10]

A final important projection is that the long-term world oil price is expected to remain more or less constant, at somewhat below $30/barrel (in 2001 dollars). The assumption here is that OPEC will continue to keep a lid on prices, as it seems, with at least limited success, to have been able to do since the 1980s; this will enable the organization to protect and increase its market share over time.

These projections, though perhaps best-guess views of future developments, are not the only plausible scenarios. Table 4 summarizes the implications of six alternative cases constructed by the EIA. A couple of noteworthy points emerge from the table: First, projections of rising oil-import dependence are not very sensitive to the rather wide range of alternative economic and technological scenarios postulated by EIA. Oil imports vary between 64.5% and 70.0% of domestic consumption across all EIA's scenarios, all of which are considerably in excess of the 53% figure for the year 2000. Second, however, the significant reduction in the nation's oil intensity characterizes all cases shown; even the least dramatic change (the case

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[9] In non-OPEC countries producing up to where price equals marginal cost, in the absence of major technological change, there is little incentive to expand future production without a significant increase in the world oil price: U.S. oil output remains essentially flat over the projection period. In contrast OPEC countries, currently producing at well below capacity, can easily and profitably respond to future increases in demand without a significant price jump.

[10] One reason for the continued decline is that vehicle miles traveled tend to grow by less than in proportion to GDP over time.

reflecting a pessimistic technological outlook) still shows a roughly 25% decline in oil intensity between 2000 and 2025.[11]

2.5 Effects of Oil Price on Aggregate Economic Activity

There are a number of ways that an oil-price increase could lead to a reduction in aggregate economic activity. On the supply side, higher input prices could raise the cost to firms of producing output, which could then induce them to cut back the level of production. On the demand side, the transfer of purchasing power from domestic consumers to overseas suppliers reduces aggregate domestic demand for goods and services.[12]

Many studies have documented an inverse empirical relation between oil prices and aggregate economic activity.[13] In an extensive survey of the early literature, Jones and Leiby (1996) find that a 1% increase in oil prices reduces GNP by around 0.02 to 0.08%, with most estimates clustered around 0.05%. At the time, these estimates were roughly equal to the share of oil expenditure in GNP; from the mid-1970s to the mid-1980s this share was around 4–6%. However this share has now fallen to below 2%, suggesting that the relation between oil prices and economic activity has weakened significantly.

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[11] These projections are sometimes held to be of limited usefulness because of EIA's mandated bar to injecting policy-change assumptions (e.g., an increase in the federal gasoline tax) in its analysis, which therefore produces what some see as "safe," "conservative," or "uninteresting" results. However, there is latitude in EIA's consideration of other policy-driven trends; for example, alternative scenarios of OPEC behavior that give rise to a range of world oil prices are considered. Moreover, EIA's alternative technology cases (such as in transportation or electric generation) have value even if uncoupled from any assumptions about changed or new policies. Imaginative users of the projections can, after all, speculate on and debate policies (say, tax breaks or R&D subsidies) needed to satisfy the technological cases and outcomes postulated by EIA. Of course, quite apart from the "hands-off" rule on policy, there is the matter of EIA's methodology and analytical framework. But we do not in this report take up those technical aspects. Readers interested in doing so will find descriptive details in Appendix G—"Major Assumptions for the Forecasts"—in *Annual Energy Outlook* 2003. The approach to international energy demand and supply projections are briefly described in EIA, *International Energy Outlook* 2003, p. 249. Assumptions underlying the "International Energy Module" component of the U.S. projections can be accessed at www.eia.doe.gov/oiaf/aeo/assumption/international.html.

[12] If the government responds to oil-price spikes by contracting the growth of the money supply, this may compound the reduction on GDP. However, analysts disagree on both the extent to which monetary policy has been used in this way, and on the extent to which it can affect GDP in the short term.

[13] See for example Mork and Hall (1980), Darby (1982), Gisser and Goodwin (1986), Hamilton (1983).

That volatility in oil prices—especially precipitous and significant increases in price—should exact an economic penalty makes intuitive sense. An oil-intensive firm faces increasing costs, whether it chose to maintain its oil input at its existing mix of productive factors or it opted prematurely to write off investments in order to adapt to new oil-market conditions. If there were many firms in this situation, or if there were major spillover effects to other firms and broad industry groups, it is easy to see why nationwide productivity and economic growth would suffer. However, the fact that the economy has become progressively less oil intensive the case for significant macroeconomic impacts of oil-price increases becomes harder to make.

From an exhaustive literature survey and analysis of the long-term oil price-GDP relationship extending to the late 90s, Brown and Yücel (2002) though circumspect in drawing firm conclusions, note that the "sensitivity of the U.S. economy to oil price shocks seems to have decreased over the past two decades." Indeed, looking at the behavior of GDP and oil prices during the most recent decade, one finds little evidence of a closely linked relationship. Of the 13 years 1990–2002, more than half exhibited an anomalous relationship between the two—small declines in GDP accompanying large declines in oil prices; trend-line growth in GDP in spite of large increases in oil prices (see Figure 6). Most striking is the year 2000—oil prices rising by two-thirds, yet GDP growth is 3.7%.

Of course the apparently weak statistical sensitivity of GDP to oil-price changes could mask a more significant underlying relationship. For one thing, without, for example, the 68% rise in oil prices in 2000, GDP might have grown much more than it did. Also, the period dating from around the mid-90s has been described by some as one characterized by some unique phenomena—notably, developments related to information technology. The effects of these developments might have dominated the effects of turmoil in energy markets. Under more normal circumstances, such effects might have been deduced from the data.

Aside from the economic impact of short-term fluctuations, concern is also expressed about the economic consequences of sustained, long-term increase in oil prices. Since, over the long run, producers have greater flexibility to alter their production function so as to accommodate to an observed trend in oil prices, one would expect a more muted impact on the GDP trend line. Whether for that reason or other explanations (including methodological quirks), it is interesting to note that EIA's most recent "oil price" cases for the period 2001–2025 discloses little measurable effect on GDP whether or not there is a large departure in the oil price from that projected in the "reference" case. Projected average annual growth in GDP varies across a very narrow range of 3.20–3.23% as the trend in oil prices to 2025 is increased and decreased by 30%.

2.6 Use of the Strategic Petroleum Reserve to Counteract Short-Term Price Volatility

The U.S. Strategic Petroleum Reserve (SPR) provides one means to calm and stabilize oil markets through timely, presidentially directed releases of emergency crude oil stocks.[14] The volume of oil in the SPR in mid-year 2003 amounts to around 600 million barrels, or around 52 day's worth of imports. Although the level of oil in the SPR has not changed much in recent years, its effective import "coverage" has fallen as the level of imports has grown over time. Coverage is now less than half of the 115 days achieved in the peak year 1985 (Figure 7). Currently, the United States has the capacity to store up to 700 million barrels, although the House-passed energy bill of early 2003 (H.R. 6) proposes raising that limit to one billion barrels.

Past episodes of significant oil-market disruptions that might have tested SPR's effectiveness in meeting the security objectives for which it was created have largely been squandered or mishandled. Decisions to release SPR oil have been strongly influenced by federal deficit reduction needs, while the opportunity to purchase oil under conditions of depressed prices was only haltingly pursued. It is certainly the case that successful deployment of SPR involves a host of uncertainties, numerous working assumptions, and consideration of how SPR strategy relates to other energy policies.

In the end, however, government policymakers confront a major benefit-cost decision: Given the potential economic cost of a major disruption in world oil supplies (and therefore of U.S. imports), how do the benefits of mitigating such economic damage compare with the cost of maintaining a strategic stockpile necessary to achieve that mitigation? Posing the question in this way makes it clear that there is no axiomatic basis for a position holding "the larger the reserve, the better."

Here, we rely on analysis reported by Leiby and Bowman (2000).[15] The authors employ a "numerical simulation model" whose estimate of gross benefits is based on SPR's ability to lessen GDP losses and oil-import costs during a disruption (these costs are explained below),

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[14] The extent to which mere existence of the reserve could deter purposeful disruptions appears not to figure in most analyses of SPR strategy and is not considered here.

[15] One virtue of that study is that its point of departure is a SPR volume of 580 million barrels—not far off from prevailing levels—and oil-market conditions close enough to the current one to lend an air of realism to the calculations.

with net benefits subtracting the cost of developing and operating the SPR. The "base case" exercise, on which the authors put major stress, yields a net benefit of between $1.5 and $1.8 billion. They say: "Moderate expansion of the U.S. reserve (on the order of at least 120 million barrels) is justified on the basis of [such] benefits to the U.S. economy alone." (p. 2) The model assumes a 1% probability of a 15% loss of world oil supplies lasting 4 ½ months. The authors are not dogmatic about the incremental fill of 120 million barrels; pointing out that, with SPR spare capacity remaining adequate, a significant decline in oil prices would favor additional buildup of the reserve.

3. Assessment of the Oil Premium

In general the United States benefits greatly from free trade and from the use of oil. However, in cases where the market for a commodity is not fully competitive, or is subject to price shocks that reverberate throughout the economy, consumption of it may involve social costs that not borne by the users of the commodity.[16] This section discusses the marginal external costs of petroleum consumption, that is, the difference between the costs to the U.S. economy as a whole and that to individuals or firms from additional oil consumption. Marginal external costs, expressed in $/BBL, are referred to as the oil premium; they reflect how much, in principle, oil use should be taxed. We assume that additional demand would be met through extra imports rather than expanded domestic production, which is a reasonable approximation.

Prior literature has identified two main sources of external costs. One has to do with how additional demand by individual importers raises the price for all U.S. importers, and the other with economic disruptions throughout the economy caused by unanticipated price shocks. The first component depends on long-run factors rather than short-term price volatility, particularly the extent of U.S. imports and U.S. monopsony power in the world oil market, accounting for responses by OPEC and other countries. The second component depends on short-term price variability (about a given long-run trend), total petroleum consumption (relative to GDP) as well as imports, and the flexibility of firms and households outside the energy sector to respond to, and insure against, changing energy costs. We discuss these cost components in more detail, and

[16] Oil consumption may also have environmental implications, but these are beyond the scope of our discussion.

then briefly comment on why U.S. military expenditures in the Middle East are usually excluded from calculations of the oil premium. Much of the following discussion is based on an excellent review by Leiby et al. (1997).

3.1 Monopsony Power

If the United States were a price taker in world oil markets, the fact that behavior by OPEC kept the world oil price above its competitive level over the long run would have no implications for the marginal external costs of U.S. oil imports (leaving aside costs from short-term price volatility). This is because the price paid by importers for extra oil would equal the cost of the extra oil to the U.S. economy as a whole; consequently individuals or firms in the United States would not consume "too much" oil from the nation's perspective. Thus, even though OPEC might be extracting large income transfers from domestic oil users by price manipulation, the oil premium is still zero, because changes in U.S. imports would have no effect on the world price.

However, the United States has market power, or more precisely, monopsony power, in the world oil market, because its consumption is a substantial fraction of total world petroleum consumption. This means that when U.S. customers as a group increase their demand for imports there is a significant effect on world demand, and the world oil price is likely to increase slightly. Higher prices raise the total amount that must be paid for all (marginal and inframarginal) U.S. petroleum consumption. Some of the extra expenditure goes to domestic suppliers; however about 60% of it goes to foreign suppliers and is effectively a transfer of dollars out of the U.S. economy to other countries. This transfer is an additional cost borne by the United States as a whole that is not taken into account by individual U.S. consumers—they consider the market price they must pay for additional barrels and not the collective effect of importers as a group on raising world prices and hence the total bill for U.S. oil imports.

The difference between the cost to the nation as a whole and the market price for extra oil imports depends on two key factors:

3.1.1 The level of U.S. oil imports

If the United States were self-sufficient in oil there would be no monopsony power externality; higher prices paid for oil would simply transfer income from domestic consumers to domestic firms with no overall loss for the economy.[17] However, the greater the gap between domestic consumption and domestic supply, the greater the transfer of purchasing power from U.S. consumers to foreign firms, following a U.S.-induced increase in the world price. Note that the portion of U.S. imports from the Middle East is irrelevant—for a given total amount of imports the transfer out of the economy is the same, regardless of whether 0% or 100% of U.S. imports come from the Middle East.

3.1.2 The effect of U.S. demand on the world oil price

If the world oil market was competitive and supply perfectly elastic, then extra U.S. demand would be met barrel for barrel by extra world supply with no effect on the world price, regardless of the share of United States in world oil demand. Again, in this case the oil premium would be zero, as changes in U.S. imports would have no effect on the world price. In practice, supply is not perfectly elastic because of OPEC behavior, which is difficult to predict. At one extreme, OPEC production may not respond at all, in which case extra U.S. demand can have a noticeable effect on price; at the other OPEC could completely neutralize the effect of changes in U.S. demand with offsetting changes in its supply. In addition to OPEC behavior, the change in the equilibrium world price will also depend on supply-and-demand responses in other non-OPEC countries.

The marginal external cost per barrel of U.S. oil imports from monopsony power (denoted E^M) can be expressed in a couple of ways (e.g. Leiby et al 1997, p.10):

$$E^M = M\frac{dp^w}{dM} = \frac{p^w}{\varepsilon}\,;\, \varepsilon = \frac{dM}{dp^w}\frac{p^w}{M}$$

The first way is to view it as the quantity of U.S. imports, M, times the increase in world price resulting from an extra barrel of U.S. imports, dp^w / dM. Alternatively, the marginal

[17] Obviously if the U.S. were a net oil exporter rather than an oil importer it would benefit, rather than lose, overall from higher world oil prices.

external cost is simply the world price divided by the elasticity of supply of U.S. imports with respect to the world price, ε.[18] A country with a small share of imports in the world market is effectively a price taker, meaning that it faces a perfectly elastic import-supply curve, $\varepsilon = \infty$ and $E^M = 0$. And even with potential monopsony power, E^M could still be zero. This would be the case if OPEC had both the ability and the desire to keep world prices at some target level by tightening their production quotas; in principle, this appears to be the Saudi strategy, however in practice it is difficult for OPEC to allocate production cuts among member countries.

Figure 8 plots p^w / ε for world oil prices of \$15, \$25, and \$35/BBL and import-supply elasticities between 0 and 20. The premium can be substantial if the import-supply elasticity is small; for example, the premium is greater than \$12/BBL if $\varepsilon < 3$ and the world price is \$25/BBL. But if the supply elasticity is 20, the premium falls to \$1.3/BBL (for p^w = \$25/BBL). Recent computations by Leiby et al. (1997) put the U.S. import-supply elasticity at between around 5 and 20;[19] this implies a premium of \$1.3/BBL to \$5.0/BBL for an oil price of \$25/BBL.[20]

3.2 Disruption Costs

Even without destabilizing behavior by OPEC, we might still expect volatility in world oil prices due to fluctuating economic conditions; for example, unexpectedly cold winters or unexpectedly rapid world economic growth can lead to transitory price spikes. Economic disruption costs from oil-price volatility have two main components, increased import costs and macroeconomic adjustment costs. We discuss each of these in turn.

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[18] This is the inverse elasticity rule for an optimum tariff that is familiar in international trade theory. Note that p^w and ε are evaluated at the optimum (reduced) level of imports, rather than at the currently observed market equilibrium.

[19] The lower elasticity scenario assumes OPEC would respond to a 1% fall in the world price by reducing their production by 1%; the higher scenario assumes OPEC would cut their supply by 5%.

[20] Estimates of the monopsony component of the premium may be biased upwards somewhat as they do not account for possible costs to the U.S. economy from the possibility of retaliation imposed on nonoil products by overseas suppliers (Canada, Mexico, Russia, OPEC, etc.) should the United States deliberately reduce its oil imports.

3.2.1 Increased Import Costs

This is the wealth transfer from domestic consumers to foreign suppliers from a temporary price increase, approximately equal to the level of U.S. imports times the price increase. Whether there is actually any externality here is somewhat questionable. If businesses and households correctly anticipate the risk of price shocks this would be factored into their decisions and there would be no externality. Unfortunately it is very difficult to judge to what extent actual price volatility might be anticipated beforehand. Analysts therefore take a wide range of scenarios; for example, Leiby et al. (1997) assume that the portion of any given price shock that is anticipated is between 25% and 100%.

There are two ways to estimate the associated component of the oil premium. The first is to infer the likelihood of future price shocks from previous experience. For example, there were five price shocks from 1973–1997, and the average price increase was 110% of the predisruption price, or $10/BBL (Leiby et al. 1997). The expected shock size per year over this period (counting no-shock years as zero) was therefore $2/BBL. Using scenarios when the portion of the price shock that is anticipated is 25% and 100% gives a premium component of $1.5/BBL or $0 respectively (in the latter case there is no premium because the risk of price shocks has already been taken into account by the private sector). Most analysts expect the future frequency and size of disruptions to be lower than in the past, though there is little agreement on how much lower.

The other approach is to attach probabilities to given supply disruptions due to OPEC and other factors in any given year, and infer the resulting price effects based on assumptions about oil demand and supply elasticities, use of the SPR, and so on. For example, in their high disruptions scenario, Leiby et al. (1997) assume 13% probability of a 1MMBD disruption each year, 3.5% probability of a 3 MMBD disruption, and 0.5% for a 6MMBD disruption. Leiby et al. (1997) compute the import cost component of the oil premium as high as $4/BBL, but typically below $1/BBL, under different scenarios for disruption probabilities. They also compute how a reduction in U.S. imports might dampen the price effect of a given supply disruption (see their Table 3).

3.2.2 Adjustment Costs

At a first glance, variability of oil prices about a given trend might appear to have approximately no effect on the expected costs of petroleum consumption. Additional energy costs in times of high prices will be roughly offset by energy savings in times of lower prices. Indeed price volatility is pervasive across many primary commodity markets, including those for agricultural products and other natural resources. What is different about oil?

There are three main linkages at issue here. First, oil is an intermediate good that is widely used by firms and households throughout the economy, outside of upstream suppliers engaged in the production, importation, and refining of petroleum. Price volatility may impose costs on others in the economy that are not taken into account by upstream oil suppliers when they are deciding how much to produce.

Second, price volatility matters for downstream, or ultimate users of oil products, because of adjustment costs. A basic result from production theory is that the short-run costs of varying output in response to changes in input prices are greater when firms have fixed factors, such as sunk investments in plant and machinery. This means that average production costs when firms have to keep changing production levels exceed average production costs when there is no need to vary output because input prices are constant over time. Other examples of adjustment costs include workers or capital temporarily unemployed as energy-intensive industries expand and contract over time with volatile oil prices (e.g., because it is costly and takes time for workers to retrain or relocate or for plants to be refurbished), or households stuck with previously purchased automobiles or investments in residential heating/cooling systems that would not have been optimal at current fuel prices. In all these examples, the presence of adjustment costs means that firms and households are worse off under variable prices than constant prices, for a given mean price.[21]

Third, adjustment costs would not matter if firms and households could perfectly anticipate and insure against volatile oil prices; that is, if they could effectively guarantee themselves a fixed price by letting other parties cover additional energy costs when prices are high and making payments to other parties when prices are low. Futures markets provide one way to hedge against price volatility; oil stockpiling and investments in flexible energy use technologies are other options. But to the extent that private markets cannot completely handle all risks associated with price volatility there is a potential market failure and a positive oil premium.

[21] For more discussion of adjustment costs see Hamilton (1988), Huntington (2001), Atkeson and Kehoe (1999).

The extent to which markets insure against oil-price volatility is largely an empirical issue that has not been fully resolved. A number of studies using aggregate time-series data find that greater oil-price volatility reduces GDP (see the review by Brown and Yücel 2002); indeed all but one of the post-World-War-II recessions have followed a sharp rise in oil prices, yet an acceleration of U.S. economic activity did not follow the oil-price declines over the past two decades. This suggests that the costs of oil-price increases exceed the benefits of oil-price reductions, and a logical explanation is that in both cases adjustment costs are incurred that have not been fully insured against.[22]

Note that it is total petroleum consumption that matters for macroeconomic adjustment costs and not the level of imports. Even if the share of imports in domestic consumption were drastically reduced through expanded domestic supply, the price of oil in the United States would still be determined by the world price, and the United States would be just as vulnerable to oil-price volatility.[23] The only way to reduce adjustment costs from oil-price volatility is to reduce the petroleum intensity of GDP.

The adjustment cost component of the oil premium is calculated using assumptions about the GNP oil-price elasticity, which is assigned values between –0.025 and –0.06 in Leiby et al. (1997); that is, an oil-price doubling will causes adjustment losses between 2.5 and 6% of GNP. Combining with scenarios for disruption probabilities yields a premium component of between \$0 and \$6.5/BBL (Leiby et al. 1997, Table 4).[24]

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[22] There is some controversy over whether oil-price shocks do in fact have significant effects on macroeconomic activity. Using disaggregate data on three-digit industries Bohi and Toman did not find larger than average output losses in energy-intensive industries relative to other industries following the 1973–74 and 1979–80 price shocks (see Bohi 1989, Bohi 1991, Bohi and Toman 1993). In other words Bohi and Toman looked for underlying factors that might explain a link between oil prices and aggregate economic activity, but could not find them. They suggested that the apparent correlation could be due instead to destabilizing monetary policy (i.e. contractionary policy to avoid cost-push inflation in response to price increases). While the view that oil-price shocks do not have significant effects on economic activity is a minority one among oil analysts, there remain unresolved issues concerning the disaggregated data.

[23] Indeed a subsidy to domestic oil producers could increase U.S. consumption to the extent that world oil prices might fall and increase disruption costs.

[24] One caveat to the above is that the aggregate economic costs mask some important distributional considerations. In particular, sudden rises in oil prices in winter can create serious social distress among low-income families who depend on oil to heat their homes. This concern is partly mitigated by the federal Low-Income Home Energy Assistance Program, and most of the New England states, which are subject to distribution difficulties, also have assistance programs of their own.

3.3 Summary, Comparison with Other Studies, and Future Projections

Leiby et al. (1997) Table 5, presents a summary combining the three components of the oil-import premium under narrower ranges of assumptions, based on their judgment of the likely range of conditions. The total premium in their preferred range lies between $0 and $4.60/BBL, equivalent to between 0 and 11 cents per gallon of gasoline; under broader assumptions their range is $0 to $10/barrel.

An earlier study by Broadman and Hogan (1986, 1988) put the oil premium at $4.3 (monopsony component) + $10 (disruptions component) = $14.5/BBL (34 cents per gallon of gasoline). Leiby et al. (1997) provide a detailed reconciliation of these differing results, and we briefly mention some of the main points here.

Updating the Broadman and Hogan analysis to simply reflect more recent oil-market conditions compared with 1985 slices $4.5/BBL from their premium. This is adjusting for (a) the lower U.S. share in the world oil market, (b) the lower market price of oil, (c) the smaller share of petroleum in U.S. GDP, and (d) the increased level of imports. The first three, (a)–(c), all serve to reduce the premium while (d) increases it. Two other adjustments of note were made by Leiby et al: allowing for a positive portion of the price shocks to be anticipated and insured against by private agents (Broadman and Hogan assumed all price shocks were unanticipated) and using lower disruption probabilities than those based solely on experience prior to 1985.

Another recent assessment by a panel of experts put the best estimate for the oil premium at $5/BBL, with an upper bound of $10/BBL (NRC 2002). This somewhat higher range mainly reflects updating over Leiby et al. (1997) for higher baseline oil prices. Other recent studies (which are less detailed than Leiby et al. 1997) are summarized in Table 5: estimates vary between $0 and $14/barrel. Differences of opinion over the magnitude of the disruptions component of the oil premium boil down to different views about how efficiently markets take into account the risk of, and respond to, oil-price shocks. Most analysts believe that the full extent of oil-market upheaval is not fully captured in firm behavior, and consequently the disruptions component of the premium is positive; it is zero under the assumption that markets fully internalize and hedge against the risk of price shocks. And most analysts allow for a positive monopsony power component; this component is zero only under scenarios when OPEC matches any reduced U.S. import demand with barrel for barrel cuts in production.

In light of these considerations we put our best assessment of the quantifiable component of the oil premium at $5/BBL, with a wide range of $0 to $14 to account for the diversity of opinion among oil analysts. These values are consistent with other recent reviews of the evidence by NRC (2002) and CEC (2003).

It is not clear how future adjustments to baseline market data may affect the oil-import premium over the next 25 years. World oil production will become increasingly concentrated in the Persian Gulf; in theory this gives OPEC more market power. However this is taken into account in projections of future world oil prices: Energy Information Administration (EIA) projects world oil prices in 2025 at about the same as current levels, with approximate range of plus or minus 30% (similar projections are offered by the International Energy Agency). Declining petroleum intensity of GDP will continue to reduce the disruptions component of the premium in the future; EIA projects oil intensity to fall by 24–34% by 2025. On the other hand the growth of the oil-import share will increase components of the premium; EIA projects growth in this share of 22–33% by 2025. Our best assessment is that, in real terms, the oil premium will remain unchanged over the next 20 years, at $5/BBL in real terms, with a margin of error of plus or minus 50%.

3.4 Persian Gulf Military Expenditures

U.S. military expenditures in the Middle East are in part the result of U.S. interests in securing its flow of imported oil from that region, and therefore count as a total cost of oil-import dependency. However, many analysts do not include them when assessing the external costs of marginal changes in U.S. oil imports.

One reason is that it is difficult to assess what portion of costs—which include recurrent costs of troops and ships in the region, as well as large one-off costs for wars involving the United States—should be assigned to imports as opposed to other political objectives, such protecting the security of Israel, reducing the threat of terrorism, and humanitarian objectives.[25] But most important reason for not counting military spending as a component of *marginal*

[25] It is difficult to know where to draw the line on what spending should be included; for example, whether to include military aid to Israel and Egypt. There have been a few attempts to quantify the military costs of oil dependency. Delucchi (1998), Table 7-23, put them at $0.6-6.8 billion for 1991, or $0.25 to $2.9 per barrel of imports, after updating to 2002 dollars.

external costs is that it does not really vary with (modest) changes in oil imports; military spending is more of a fixed cost than a variable cost. A policy to moderately reduce imports over time, and that did not entirely eliminate import dependency, would probably have little benefit in terms of cutting the costs of U.S. military involvement in the region.

4. Concluding Remarks

There remains substantial dispute over the magnitude of the oil premium. Recent estimates vary between about $0 and $14 per barrel, equivalent to between 0 and 33 cents per gallon of gasoline; our preferred value is $5 per barrel. In principle, the social costs of oil dependency call for a modest tax, though the tax should be on all oil uses, not just those related to transportation. Although economically efficient, a broad oil tax would not have a dramatic effect on oil use in the short term, as the demand for oil is only moderately sensitive to higher prices. However, by increasing incentives for the development of energy-efficient technologies, its long-term impact could be more substantial.

The gasoline tax (combining federal and an average of state taxes) is currently around 40 cents per gallon, much larger than the oil premium. However the tax also addresses, albeit very imperfectly, a number of other social costs associated with automobiles including local and global air pollution, traffic congestion, and accidents. A recent assessment by Parry and Small (2003) put the economically optimal fuel tax to address these other social problems, leaving aside the oil premium, at around $1 per gallon; this suggests that the extent to which fuel is currently undertaxed from other perspectives is significantly greater than what is implied by even the highest end of the oil premium range.[26]

[26] Gasoline tax revenues also fund highway spending, though whether this justifies setting a tax rate in excess of that required to address the social costs of congestion, oil dependency and so on is a tricky issue. It depends on whether the economic costs of raising revenues from higher fuel taxes (ignoring congestion, oil dependency, benefits, etc.) are greater or less than the economic costs of raising revenues from other sources, such as personal income taxes. Higher income taxes are costly in terms of economic efficiency as they, albeit moderately, reduce incentives for work effort, human capital accumulation and saving. Fuel taxes are costly as they raise transportation costs for households and firms and depress the overall level of economic activity.

Higher fuel taxes have proved to be politically difficult, however.[27] Other measures to encourage greater oil conservation include higher fuel economy standards for new passenger vehicles; current standards are 27.5 miles per gallon for cars and 20.7 miles per gallon for light-duty trucks (minivans, sport utility vehicles, pick-ups). Tighter standards could encourage manufacturers to modify vehicle design in a variety of ways to improve fuel economy, however they are less efficient than higher gasoline taxes. By lowering fuel costs per mile they encourage people to drive vehicles more, increasing traffic congestion and accidents; in contrast higher fuel taxes raise the cost of driving. And, unlike fuel taxes, they do not encourage households to conserve fuel through better vehicle maintenance, driving behavior, and making more use of existing fuel efficient vehicles (e.g. using the car rather than the sport utility vehicle for errands).

Other policies that could encourage reduced oil dependence over time include subsidies for the development of alterative fuel technologies (e.g., hydrogen and electric vehicles, hybrid gasoline-electric vehicles), either through government provided R&D or subsidies for private R&D. In the absence of government policy, such R&D efforts by the private sector alone may be inadequate due to the inability of innovators to capture spillover benefits of new technologies to other firms. The case for encouraging domestic oil production to displace oil imports appears less convincing; much of the macroeconomic disruptions component of the oil premium depends on total oil consumption and not the share of it that comes from oil imports. This raises questions about the energy security argument for allowing drilling in, for example, the Arctic National Wildlife Refuge, though environmental and economic considerations should also be factored into any policy decision on drilling restrictions.

Finally, an argument could be made for more active use of the Strategic Petroleum Reserve in times of severe oil market disruptions, particularly if actions could be coordinated with other large oil-importing regions. To be sure private firms can be expected to include disruption risks in their inventory and other strategies. Still, there is a wide body of professional writing suggesting that the full extent of oil-market upheavals is far from captured in firms' behavior. SPR is a defensible instrument for compensating for that gap.

[27] The Clinton administration managed to increase the federal gasoline tax by only 4 cents per gallon in 1993, despite a major effort. The tax has declined in real terms since then.

References

Adelman, M.A., and M. Shahi. 1989. Oil Development-Operating Cost Estimates, 1955-85." *Energy Economics* 11: 2–10.

Atkeson, A., and P.J. Kehoe. 1999. Models of Energy Use: Putty-Putty vs. Putty-Clay. *American Economic Review* 89: 1028–1043.

Bohi, D.R.. 1989. *Energy Price Shocks and Macroeconomic Performance*. Washington, DC: Resources for the Future.

———. 1991. On the Macroeconomic Effects of Energy Price Shocks. *Resources and Energy* 13: 145–162.

Bohi, D.R., and M.A. Toman. 1993. Energy and Security: Externalities and Policies. *Energy Policy* 21: 1093–1109.

Broadman, H.G., and W.W. Hogan 1986. Oil Tariff Policy in an Uncertain Market. Discussion paper E-86-11. Cambridge, MA: Energy and Environmental Policy Center.

———. 1988. Is and Oil Import Tariff Justified? An American Debate: The Numbers Say 'Yes.' *The Energy Journal* 9: 7–29.

Brown, S.P.A,. and M.K. Yücel 2002. Energy Prices and Aggregate Economic Activity: An Interpretive Survey. *Quarterly Review of Economics and Finance* 42: 193—208.

California Energy Commission (CEC). 2003. *Benefits of Reducing Demand for Gasoline and Diesel*. Sacramento, CA: California Energy Commission.

Dahl, C., and M. Yücel. 1991. Testing Alternative Hypotheses of Oil Producer Behavior. *The Energy Journal* 12: 117–138.

Darby, M.R.. 1982. The Price of Oil and World Inflation and Recession." *American Economic Review* 72: 738-751.

Delucchi, M.A. (1998). *Motor-Vehicle Infrastructure and Services Provided by the Public Sector*. Report #7 in the series: *The Annualized Social Cost of Motor-Vehicle Use in the United States, based on 1990-1991 Data*. Report UCD-ITS-RR-96-3(7), Institute of Transportation Studies, University of California, Davis.

Energy Information Administration, 2002. *Annual Energy Review 2001*. Washington, DC: U.S. Department of Energy.

Energy Information Administration, 2003. *Annual Energy Outlook 2003*. Washington, DC: U.S. Department of Energy. Available at: www.eia.doe.gov/oiaf/aeo/index.html.

Energy Modeling Forum, 1992. "International Oil Supplies and Deamnds." EMF Report 11, vol II, Energy Modeling Forum, Stanford University, Stanford, CA.

Gisser, M. and T.H. Goodwin, 1986. "Crude Oil and the Macroeconomy: Tests of Some Popular Notions." *Journal of Money, Credit and Banking* 18: 95-103.

Greene, D.L. and P.N. Leiby, 1993. *The Social Costs to the US of Monopolization of the World Oil Market, 1972-1991*. ORNL-6744. Oak Ridge, TN: Oak Ridge national Laboratory.

Griffin, J.M., 1985. "OPEC Behavior: A Test of Alternative Hypotheses." *American Economic Review* 75: 954-963.

Hamilton, J.D., 1983. "Oil and the Macroeconomy since World War II." *Journal of Political Economy* 96: 593-617.

Hamilton, J.D. 1988. "A Neoclassical Model of Unemployment and the Business Cycle." *Journal of Political Economy* 96: 593-617.

Huntington, H.G., 1991. "Inferred Demand and Supply Elasticities from a Comparison of World Oil; Models." EMF WP 11.5, Energy Modeling Forum, Stanford University, Stanford, CA.

Huntington, H.G., 1993. "OECD Oil Demand." *Energy Economics* 15: 49-56.

Huntington , H.G., 2001. "Oil Security as a Macroeconomic Externality." Discussion paper, Stanford University.

Jones, C., 1990. "OPEC Behavior Under Falling Oil Prices: Implications for Cartel Stability." *The Energy Journal* 11: 117-129.

Jones, D.W. and P.N. Leiby, 1996. "The Macroeconomic Impacts of Oil Price Shocks: A Review of the Literature and Issues." Oak Ridge National Laboratory.

Leiby, P.N. and D. Bowman, 2000. "The Value of Expanding the U. S. Strategic Petroleum Reserve," Oak Ridge National Laboratory, Oak Ridge, TN.

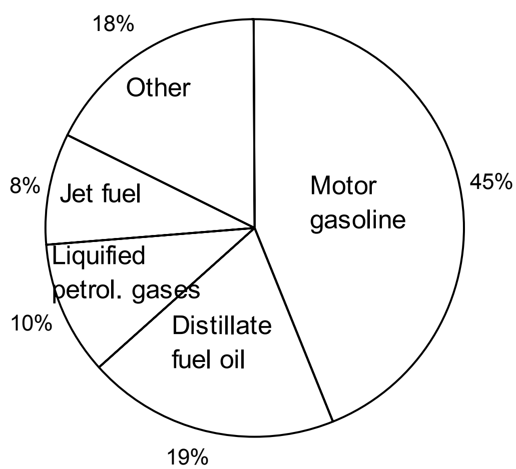
Leiby, P.N., D.W. Jones, T.R. Curlee and R. Lee, 1997. *Oil Imports: An Assessment of Benefits and Costs*. Oak Ridge National Laboratory, Oak Ridge, TN.

Mork, K.A. and R.E. Hall, 1980. "Energy Prices, Inflation and Recession, 1974-1975." *The Energy Journal* 1: 31-63.

NRC, 2002. *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*. National Research Council, Washington, DC, National Academy Press.

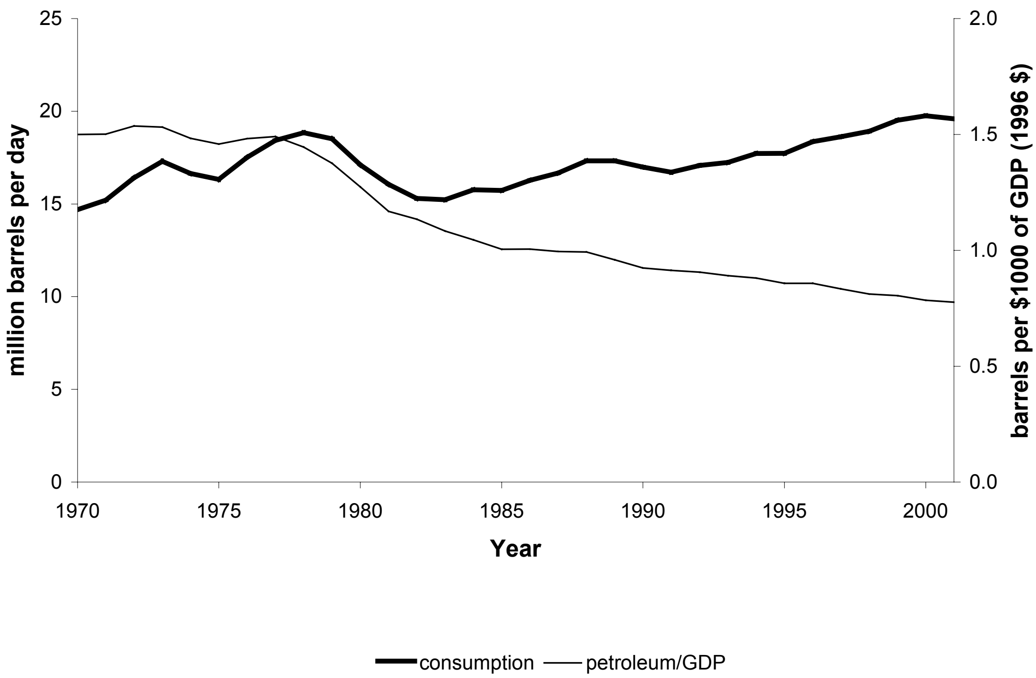
Parry, I.W.H and K.A. Small, 2003. "Does Britain or The United States Have the Right Gasoline Tax?" Discussion paper, Resources for the Future, Washington, DC.

Figure 1. Uses of Petroleum by Product 2001



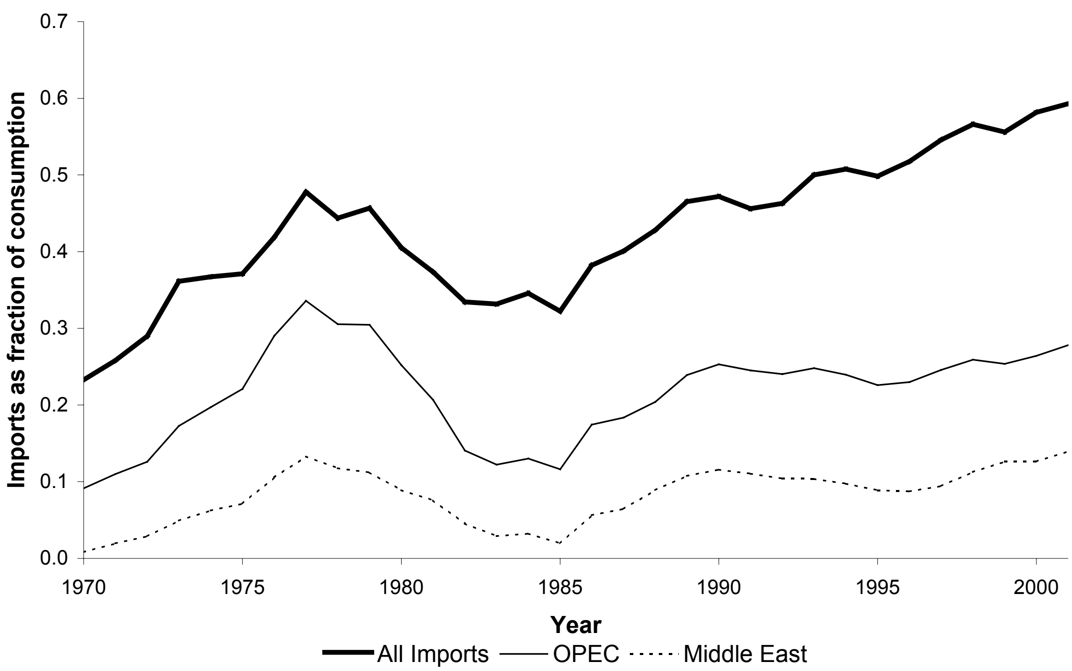
Source: Energy Information Administration (2002), Table 5.11.

Figure 2. Trends in Petroleum Consumption



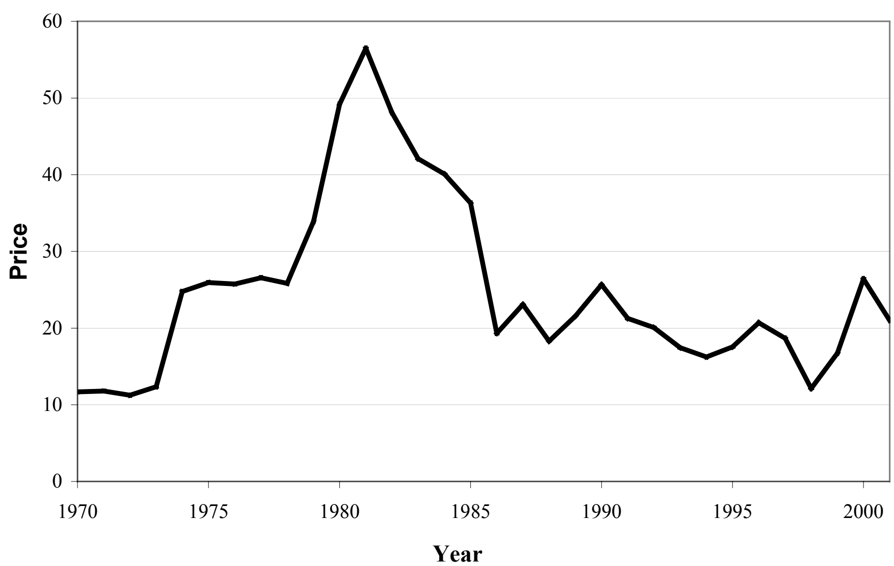
Source: Energy Information Administration (2002).

Figure 3. Fraction of US Petroleum Consumption from Imports



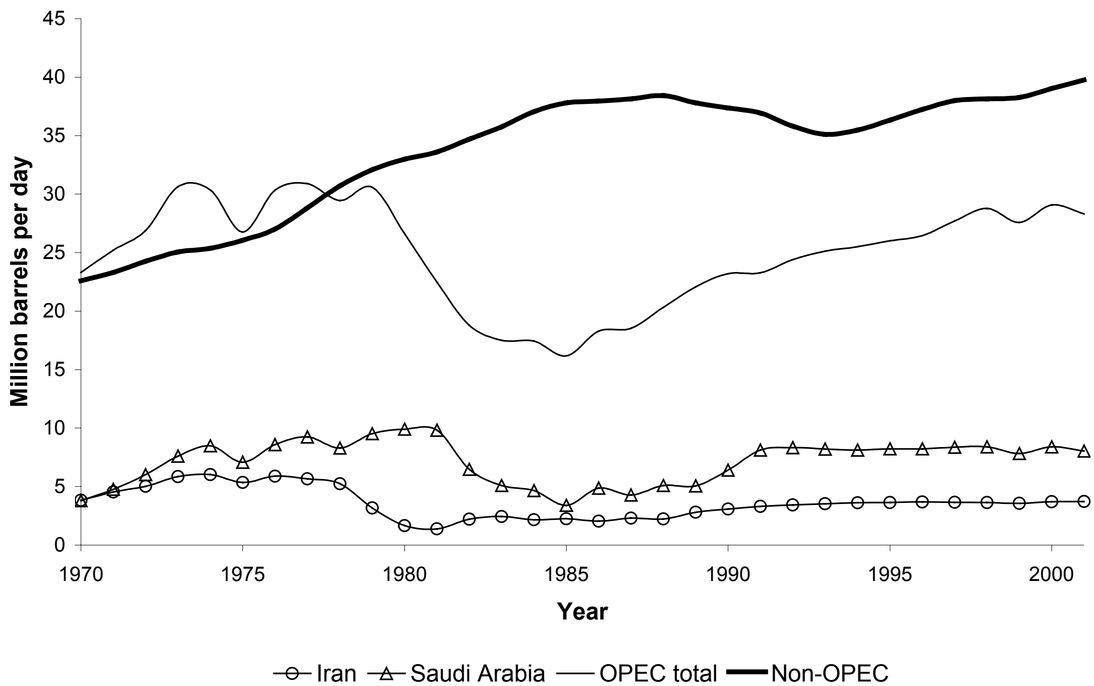
Source: Energy Information Administration (2002), Table 5.4.

Figure 4. Oil Prices, 1970-2001
(refinery acquisition price in $1996 per barrel)



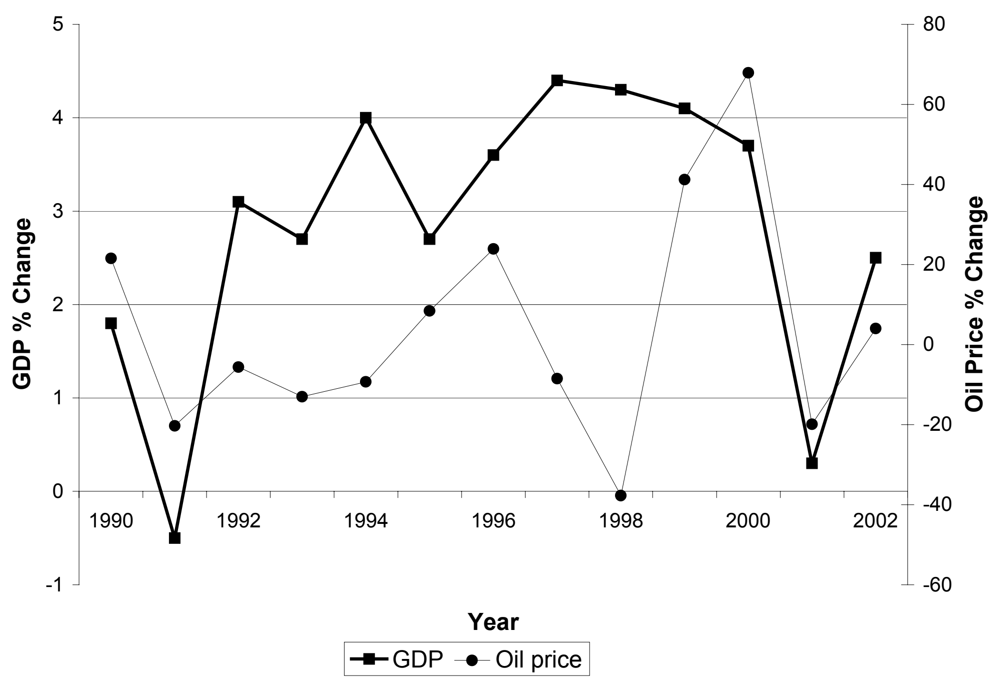
Source: Energy Information Administration (2002).

Figure 5. Crude Oil Prodution by Country/Region



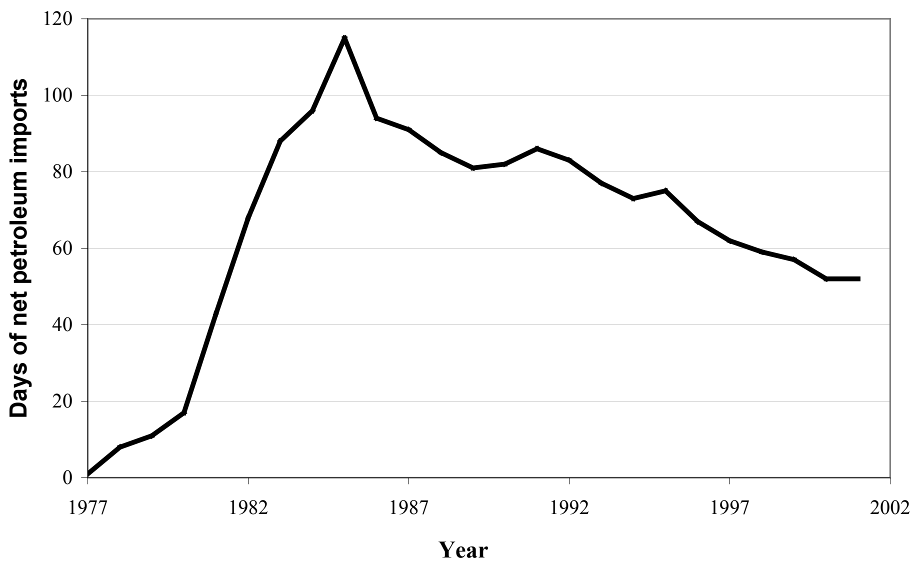
Source: www.eia.doe.gov/international.

Figure 6. Percent Change in Oil Price and GDP



Source: EIA (2002).

Figure 7. Import Coverage from the SPR



Source: www.eia.doe.gov/emeu/aer/pdf/pages/sec5-193.pdf.

Figure 8. Calculations of Monopsony Premium

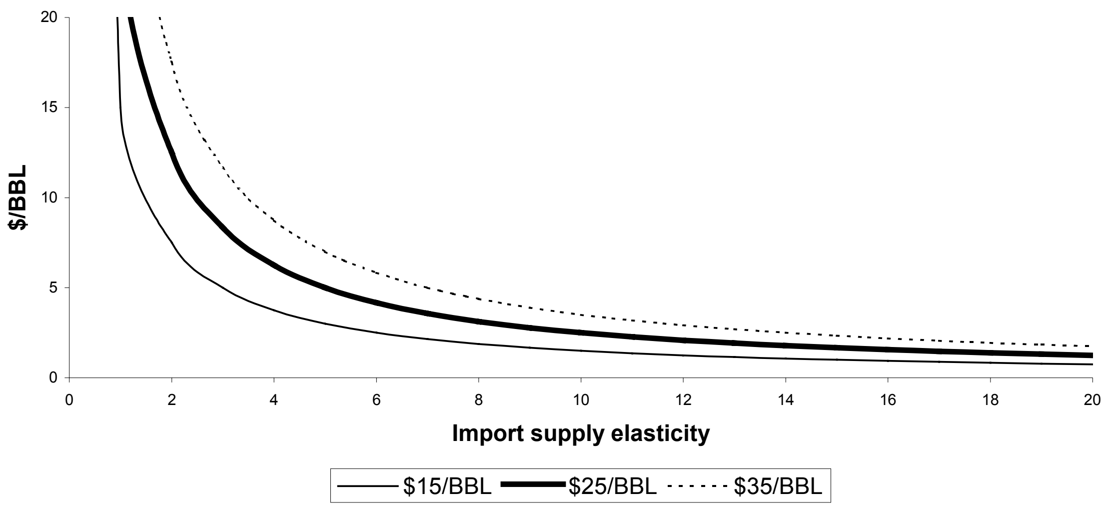


Table 1. World Oil Consumption by Region, 2002

Country/Region	% of world total	
Total OECD		61.3
United States	25.4	
Japan	6.9	
OECD in Europe	19.5	
Other OECD	9.6	
Non-OECD		38.7
Former USSR	5.1	
China	6.8	
Other Asia	10.0	
Other non-OECD	15.9	
World total		100.0

Source: www.eia.doe.gov/emeu/ipsr/t24.xls.

Table 2. Oil Supply and Reserves by Region, 2001

Region/Country	Current Production: Million barrels per day	Current Production: % of world total	Known economic reserves: Billion barrels	Known economic reserves: % of world total
Selected OPEC Producers				
Iran	3.7	5.5	99.1	9.7
Iraq	2.4	3.6	115	11.3
Kuwait	2.0	3.0	98.8	9.7
Saudi Arabia	8.0	11.8	261.7	25.7
United Arab Emirates	2.3	3.3	62.8	6.2
Persian Gulf total	**19.2**	**28.2**	**652.0**	**64.0**
Venezuela	2.9	4.2	50.2	4.9
Nigeria	2.3	3.3	30	2.9
Non-Persian Gulf OPEC total	**9.1**	**13.4**	**107.0**	**10.5**
OPEC Total	**28.3**	**41.6**	**759.0**	**74.4**
Selected Non-OPEC Producers				
Canada	2.0	3.0	5.4	0.5
China	3.3	4.8	29.5	2.9
Mexico	3.1	4.6	23.1	2.3
Norway	3.2	4.7	10.3	1.0
Former USSR	0.0	0.0	13.2	1.3
Russia	7.1	10.4	53.9	5.3
United Kingdom	2.3	3.3	4.6	0.5
United States	5.9	8.6	22.4	2.2
Non-OPEC Total	**39.8**	**58.4**	**260.8**	**25.6**
World total	**68.1**	**100.0**	**1018.7**	**100.0**

Source: *World Oil*, 223 (8), 2002 (August). The reserve estimates are crude oil resources that have been discovered and would be economic to produce at prices similar to those in recent years.

Table 3. Projected U.S. Oil Import Dependence: Some Relevant Numbers

	1990	2000	2025
Net oil imports as percent of total U.S. supply	42.1	52.8	67.9
World oil price ($2001/barrel)	27.5	28.3	26.5
World crude oil production (mill. barrels/day)	60.6	76.7	122.9
Of which: OPEC share (percent)	38.3	40.2	49.8
U.S. Petroleum Consumption (MBD)	17.1	19.6	28.7
Oil Intensity [a]	5.0	4.2	2.8

Sources: U.S. DOE, EIA, *Monthly Energy Review*, May 2003; and *Annual Energy Outlook 2003*. The 1990 real oil price was calculated by deflating (using the GDP deflator, from *Economic Report of the President*, February 2002) the current price percentage change between 1990 and 2000.

[a] Oil intensity refers to 1,000 Btu's of nationwide oil consumption per $1 of GDP expressed in 1996 prices.

Table 4. Oil-Import Dependence and Oil-Import Intensity, 2025

	Oil-Import Dependence [a]	Oil-Import Intensity [a]
High world oil price	64.5	2.9
Low economic growth	66.4	3.1
Advanced technology	66.7	2.8
Reference case	67.9	2.8
Base year technology	69.3	3.2
High economic growth	69.7	2.9
Low world oil price	70.0	3.1
(Memo: data for year 2000	52.8	4.2

[a]Oil-import dependence is defined, as in Table 3, as net oil imports as percent of total U.S. supply; oil-intensity refers to 1,000 Btu's of nationwide oil consumption per $1 of GDP expressed in 1996 prices.

Note: Because of data unavailability, the technological cases in the oil-import column refer to technologies particular to the oil and gas industries; the technological cases in the oil-intensity column refer to an "integrated" technological scenario across various sectors.

Source: Adapted from U.S. DOE, EIA, *Annual Energy Outlook 2003*.

Table 5. Oil Premium Estimates from Other Studies

Study	Estimate, $ per Barrel
Energy Comission (1994)	13.0
Behrens et al. (1992)	4-13
Delucchi (1997)	0-5
NRC (2002)	5
Ketchen and Komanoff (1992)	14
Mackenzie et al. (1992)	11
Leiby et al. (1997)	0-10

Source: CEC (2003).