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# SHOULD GNP IMPACTS PRECLUDE OIL TARIFFS?

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*Special Feature*

# Should GNP Impacts Preclude Oil Tariffs?

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The oil security issue has been pushed once again to the forefront of energy policy deliberations. While a number of different policy options are being considered and discussed, none has generated as much heated debate as the imposition of an oil import tariff in the United States (see Broadman and Hogan, 1986; U.S. Department of Energy, 1987.)

The recent *Energy Security* report (U.S Department of Energy, 1987) has challenged the wisdom of a tariff on the grounds that it would impose substantial macroeconomic penalites on the U.S. economy. While acknowledging the benefits of extracting increased wealth from oil producers, the DOE analysis concluded that the losses in real gross national product (GNP) will dramatically dwarf these wealth gains.[1] For example, if oil prices remain on a relatively low path, rising by about $1 per year in real terms, the wealth gains from a $10 per barrel tariff would be $45 billion (1985$) compared to real GNP losses of some $190 billion. Thus, it comes as no surprise that the DOE study argues strongly against the tariff as insurance against future oil disruptions. A study conducted by Data Resources, Inc. supports the argument that the GNP losses from a $5 per barrel tariff would be sizable.[2]

As a result, the economic analysis behind this policy debate is tied to a single issue. Estimates of the oil wealth gains from oil tariffs or of the macroeconomic impacts of future disruptions are not being contested. Instead, the focus has shifted to an issue that lies outside the realm in which many energy analysts feel comfortable. What are the macroeconomic consequences of a large consuming country's decision to increase its oil price in an effort

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1. Wealth gains refer to the increased national income from paying a lower price for oil imports. GNP losses represent the reduction in output in value-adde terms. See Horwich and Weimer (1984) and Huntington and Eschbach (1987).

2. The DRI study assumed that world oil prices would be unchanged by the tariff. Thus, all of the tariff would be passed through to the U.S., generating no wealth gains. The analysis did not attempt to measure any benefits that might result from reducing the costs of a possible future disruption.

to reduce the damage of future oil price shocks? Note that this issue is more general than the oil tariff issue and applies to other energy security measures as well. For example, the filling of oil stockpiles for release during future disruptions places upward pressure an oil prices when the oil is being purchased (Teisberg, 1981). Given the huge economic impacts, shouldn't countries refrain from any policy that raises their oil price in the near term?

The emphasis on the GNP losses of oil tariffs appears to be overstated and misplaced. This conclusion should hold regardless of one's view on the wisdom or fallacy of an oil tariff. While higher U.S. oil prices resulting from an oil tariff would reduce real GNP in this country, the DOE analysis underlying Energy Security has overstated these impacts because the GNP reductions were represented as permanent losses from a one-time increase in oil prices.[3] Using the basic DOE analytical framework, I show in the next section that substantially smaller GNP losses than those estimated by DOE would result from oil tariffs if these reductions in output are purely transitory in nature. Since the distrinction between permanent and temporary reductions in GNP is critical, we then show how the DOE estimates would have changed if their loss function had incorporated the transitory as well as long-lasting impacts on aggregate output. Moreover, the GNP effects can be ameliorated through other policies which would be easier to implement with a tariff than with a disruption. Conclusions and some general reservations about the current state of oil tariff analysis are discussed in the final section.[4]

## THE DOE ESTIMATES

While *Energy Security* contains an extensive and useful discussion of the macroeconomic impacts of energy price increases, its estimates of the real GNP losses due to a tariff were undermined by what would appear to be at first glance an innocuous assumption. Rather than using any particular macroeconomic model to generate the GNP losses, the study developed the following simple GNP loss function:

$$Y_t/Y_{0t} = (P_t/P_{0t})^{-a} \tag{1}$$

where $Y$ represents real GNP, $P$ is the oil price, $a$ is the "elasticity" of GNP with respect to oil prices, the subscript 0 denotes baseline values, and $t$ denotes the year. This function explicitly states that a one-time permanent

3. Alternatively, Hogan (1987) has criticized these estimates as "the $200 billion surprise". Since temporary adjustment costs are experienced each year, the economy must be surprised every year by the $10 import fee.

4. See the Appendix to this article.

**Table 1. GNP Losses From $10 per Barrel Tariff: Permanent versus Temporary Loss Functions (1985 $Billions)**

| | Loss Functions[a] | |
|---|---|---|
| Year | Permanent | Temporary |
| 1988 | 44 | 44 |
| 1989 | 41 | −5 |
| 1990 | 38 | −4 |
| 1991 | 34 | −5 |
| 1992 | 31 | −4 |
| 1993 | 29 | −3 |
| 1994 | 28 | −2 |
| 1995 | −5[b] | −33 |
| Present Value in 1987 | | |
| Real GNP Losses | 173 | 10 |
| Oil Wealth Losses[c] | −45 | −45 |

[a] Permanent losses are calculated from Eq. 1 and temporary losses from Eq. 2, using DOE elasticity of .021.

[b] This gain represents the benefits of a smaller disruption attributable to the tariff—disrupted oil prices are almost $4 per barrel less with the tariff in the DOE analysis. We have also excluded the $27 billion loss DOE reported because the analysis explicitly assumes that the tariff is removed during the disruption.

[c] DOE estimate. Efficiency losses are subsumed under GNP losses.

increase in the oil price will reduce real GNP in the current period as well as in all future periods by the same proportional amount. The losses in the tenth year are exactly equal to those in the first year. To counterbalance this deficiency in its GNP loss function, the DOE chose an elasticity representative of the first-year response, which it reasoned would act as an average impact for all years. While the impacts for the fifth and tenth year after an oil price change would be overstated by this simple rule, the GNP reductions in the second and perhaps third year would probably be understated.

The results of the DOE analysis for one of its scenarios have been duplicated in the first column of Table 1, using an elasticity (the parameter $a$ in Eq. 1) of .021 that the DOE selected after reviewing other model results and studies (including a comparison by the Energy Modeling Forum (1987) to be discussed shortly). The analysis assumes that a $10 per barrel tariff is imposed in 1987 and that a disruption occurs with certainty in 1995.

Suppose, however, that the DOE had used an alternative loss function that linked deviations in real GNP from its long-run potential output level (denoted by an asterisk) to changes in the oil price. The rate of capacity utilization measures the ratio of actual to potential output. Oil shocks will decrease the rate of capacity utilization through temporary reductions in demand. The extent of this decrease is assumed to be directly related to how much the actual oil price exceeds its expected level:

$$Y_t/Y_t^* = (Y_{0t}/Y_{0t}^*)(P_t/\hat{P}_t)^{-b}, \tag{2}$$

where $Y$ represents actual real GNP, $\hat{P}$ denotes the expected price, and $b$ is the oil price elasticity for actual GNP. If decision makers could correctly anticipate all oil prices changes as well as adjust other prices immediately to these changes, this equation states that actual output would always be maintained at its full-employment level. If all GNP losses are temporary, oil prices will not affect potential output and $Y_t^* = Y_{0t}^*$. Now if decision makers expect that the current oil price will equal last year's level and are surprised when this doesn't happen,[5] $\hat{P}_t = P_{t-1}$ and the loss function reduces to:

$$Y_t/Y_{0t} = (P_t/P_{t-1})^{-b}. \tag{3}$$

This specification states that a one-time permanent increase in the oil price would reduce real GNP in the first year. However, after the economy had adjusted to the oil price change in the second and succeeding years, real GNP would return to its long-run potential output level.

The implications of using the same elasticity value in the temporary GNP loss function (3) rather than the permanent GNP loss function (1) are dramatic, as displayed in the second column. The present value of the real GNP losses, using a ten percent real discount rate (required by the Office of Management and Budget for all federal government studies), falls from $173 billion (1985 $) in the DOE approach to $10 billion when GNP losses are treated as entirely temporary.[6] The tariff continues to drain the U.S. economy year-after-year in the DOE analysis. When losses are temporary, the tariff creates adjustment losses in the first year. Thereafter, it produces slight improvements in real GNP because the tariff has a larger depressing effect on the world oil price over time in the DOE scenarios. As a result, the economy gains back some of its initial losses because U.S. oil prices rise less over time with a tariff than without one.

In addition, even if world oil prices were unaffected by the policy, the tariff would help insulate the U.S. economy from the yearly increases in the world

5. This assumption is a simple representation of behavior governed by adaptive expectations, which is central to most econometric macroeconomic models. Given the fairly flat trajectory of oil prices (except for the shocks) in the DOE scenarios, this assumption appears acceptable.

6. Hogan (1987) was the first to criticize the DOE estimates for failing to reflect the transitory nature of much of the GNP loss. His revisions of the DOE estimates call for somewhat larger losses in real GNP—about $25 billion—than estimated here because he excludes the impacts in the 1989–94 period, which are slightly positive using our approach. He also examines the implications of using a lower discount rate and extending the horizon beyond the year of the disruption, 1995.

oil price assumed by DOE in the analysis. Percentage price increases are noticeably lower than world oil price increases when domestic prices include a substantial tax. For example, the U.S. oil price shown in Table A.1 increases 7.7 percent in 1991 without the tariff but rises only 2.3 percent in the same year with the tariff in place. This point emphasizes that oil taxes (end use and gasoline levies as well as import fees) can cushion oil-using economies from extreme oil price volatility, as they have done in many European countries.

In summary, the discounted GNP losses substantially exceed the discounted wealth gains of a tariff, estimated by DOE to be $45 billion,[7] if they are viewed as being permanent. These GNP losses are substantially less than these wealth gains if they are solely temporary. Even if the elasticity were doubled when using the alternative rule, GNP losses would remain less than $20 billion, well below the wealth gains estimated by DOE. Clearly, the dynamic pattern of the GNP losses is a critical factor that essentially determines the direction of the cost-benefit answer. We now turn to this important issue.

## REVISING THE DOE LOSS FUNCTION

Oil shocks cause both permanent and temporary reductions in real GNP (U.S. Department of Energy, 1987: Energy Modeling Forum, 1987). Potential output declines because (a) the productivity of existing capital and labor is reduced and (b) over time capital stock formation is retarded by higher energy prices. In addition, the economy produces at lower levels of capacity because price rigidities cause temporary losses as the economy tries to adjust its factor price and inputs to fit new economic conditions. Aggregate spending falls as prices increase, real disposable income declines, and interest rates rise.

While it may be preferable to estimate GNP losses from a well articulated model of the economy, the DOE apparently decided that it would be easier to explain its results with a simple GNP loss function instead. For this reason, we focus here primarily upon how to combine both permanent and temporary reductions in GNP into a simple loss function. Permanent losses in potential output are captured by (1) where additional output ($Y$) is replaced by potential output ($Y^*$). Combining Eqs. 1 and 2 yields:

$$Y_t/Y_{0t} = (P_t/P_{0t})^{-a}(P_t/P_{t-1})^{-h}, \qquad (4)$$

7. Technically, the wealth losses would change with the different macroeconomic loss function because oil prices are affected by GNP. Since our focus is on the nature of the GNP losses, we have opted to remain with the DOE oil wealth estimates. We also exclude the DOE estimates of efficiency losses due to misallocated resources because they are already included in the reductions in GNP if oil is viewed as an input to production. See Horwich and Weimer (1984).

**Table 2. GNP Losses From $10 per Barrel Tariff: Combined Loss Function (4) (1985 $Billions)**

| Loss Function Calibrated to Results from: | Present Value in 1987 Real GNP Losses |
|---|---|
| DRI Tariff Analysis (1987) | 98 |
| EMF Study (1983): | |
| DRI | 53 |
| Hickman-Coen | 35 |

where $\hat{P}_t$ has been replaced with $P_{t-1}$ in (2). The first term on the right-hand side represents the long-term reduction in potential output, while the second term incorporates the temporary adjustment losses due to a shock.

It should be emphasized, at the outset, that any aggregate loss function should be viewed simply as a rule of thumb not as a precise estimate to be relied upon for policy purposes.

Rather than use an elasticity relating percentage changes in GNP and oil prices, our analysis relies upon estimates of the GNP response to the increase in oil price in $ per barrel. This specification incorporates the fact that when real oil prices fell sharply in 1986, oil's relative importance in the economy declined proportionately. Hence, an oil price shock of a certain percentage magnitude should have a smaller proportional impact on GNP.[8]

This loss function has been based upon several different estimates of the impact of oil prices on real GNP over a four-year period. The parameter $a$ has been calculated to equal the average annual response in potential output. These losses will persist every year the tariff or shock is experienced. The parameter $b$ has been calibrated so that the temporary losses equal the cumulative discounted yearly declines in GNP adjustment losses over the four years. Thus, the adjustment losses for four years are discounted and assumed to occur all at once during the first year.

The first entry in Table 2 reports the results when this loss function has been calibrated to the recent DRI analysis (Yanchar and Caton, 1987) of a $5 oil tariff mentioned previously. The other two results refer to earlier estimates reported in a model comparison study by the Energy Modeling Forum (1987), showing the impact of a permanent international price shock of $7.20 per barrel in 1983 (or about $80 per barrel in today's prices). The DRI estimates are representative of the median results for the study. The Hickman-Coen results offer an interesting contrast in that they use an annual neoclassical growth model that incorporates short-run business cycle dynamics. While the GNP losses in the DRI and Hickman-Coen models were

8. Rowen and Weyant (1987) make a similar adjustment in their estimates of the losses due to a future disruption.

similar in magnitude, the latter attributed less of the reduction in GNP to declines in potential output. As a result, the estimated future GNP losses are some $20 billion less when the loss function in calibrated to this model.[9]

By representing the GNP impacts of oil price increases as only permanent losses, the DOE estimates far exceed a range of estimates based upon (4). But the GNP impacts remain sizable and are substantially greater than if all GNP losses had been represented as transitory. In fact, in several cases, these GNP losses exceed the oil wealth gains estimated by the DOE at $45 billion. In general, however, the uncertainty and imprecision inherent in the use of simple aggregate loss functions or in the macroeconomic response to oil prices make it inadvisable either to support or to undermine a proposal for an oil import tariff on the basis of these macroeconomic estimates alone. Moreover, the GNP losses themselves can be ameliorated to some extent through a gradual phase-in of the tariff, revenue recycling, and other coordinated economic policies.

## IS AN OIL TARIFF SIMPLY ANOTHER DISRUPTION?

In this analysis the macroeconomic impacts of an oil tariff have been treated analogous to those of an oil supply disruption. The EMF comparison revealed that the macroeconomic models represented the effects of domestic and foreign oil price shocks on GNP as being similar.[10] Moreover, oil price shocks from whatever source do confront policymakers with a pernicious tradeoff. Oil shocks reduce output and send prices higher. Traditional macroeconomic policies that augment aggregate spending will mitigate the reductions in real GNP at the expense of even higher prices throughout the economy. Tax rate reductions will also increase the federal deficit, a particularly troublesome concern for the United States these days. This dilemma often leads policymakers to refrain from using accommodating policy during a disruption and may do so for an oil tariff as well.

However, some important conceptual differences should be noted. In general, these differences suggest that the impact of an oil tariff are probably less than a comparable unexpected price shock affecting the world economy.

9. While one represents a tariff and the other an international oil shock, the two DRI results are actually more similar to each other when expressed in terms of the percentage change in the oil price. The Appendix discusses the reasons for this similarity and the implications for analyzing oil shocks.

10. This result underscores the fact that most of the models attribute the output losses more to the increase in energy prices than to a loss of income. Assumptions about how domestic tax revenues are spent could lead to some differences between the two types of shocks, particularly in those models attributing a greater role to fiscal drag.

First, oil disruptions are surprises, while oil tariffs are planned. Some of the adjustment costs associated with disruptions arise because decision makers in the oil-importing country do not expect the price shock. Therefore, the wages and prices they negotiate do not generally incorporate such events. Surprise shocks should generate greater costs than anticipated ones, although it is difficult to assess the magnitude of such a difference.

Second, since oil tariffs are planned, it may be easier to coordinate them with other macroeconomic policies, thereby mitigating some of the adverse consequences for the oil-importing country's GNP. Monetary accommodation and legislative changes in tax rates can be cumbersome mechanisms for reducing the impacts of a sudden and temporary disruption because they often cannot be timed appropriately to alleviate the losses. They could be more effective for offsetting the recessionary effects of a planned tariff.

Third, accommodating policies used in conjunction with a tariff are unlikely to cause petroleum prices to rise very much, if at all, given today's soft oil market conditions.[11] The same policies used during disruptions could induce higher oil prices because world oil market conditions are tighter.

Fourth, the oil tariff can be phased in gradually over time. This approach would diminish the size of the initial shock and push some of the negative GNP impacts of a tariff into later years. Therefore, in principle it would be possible to design a tariff to produce positive economic benefits. For example, a $10 per barrel tariff could be imposed in yearly increments of $2 per barrel, beginning in 1988. Under these assumptions, the net present value of the GNP losses would decline by almost $20 billion when the loss functions based upon the EMF study is used. The resulting GNP losses from the tariff would be less than the oil wealth gains, regardless of whether the DRI or Hickman-Coen loss functions based upon the EMF study is used.

And fifth, oil disruptions raise oil prices in all countries, severely depressing world economic activity. U.S. exports suffer as foreign incomes fall.[12] By contrast, an oil tariff raises the U.S. oil price but reduces foreign oil prices.[13] Thus, foreign economies expand rather than contract, increasing the demand for U.S. goods. Even if this effect is completely offset by the fact that foreign goods become more competitively price relative to U.S. goods after the tariff,

11. By analogous reasoning, tariffs would not initially reduce the world oil price much. In fact, this condition appears to be reflected in the DOE analysis. See Table A.1.

12. This decline becomes larger (smaller) if prices of foreign goods rise less (more) than those of U.S. goods.

13. It is sometimes argued, incorrectly, that the lower world oil price could induce greater world oil consumption and reliance upon Persian Gulf supplies than without the tariff. This argument fails to realize that the *source* of the decline in the world oil price is itself the decline in world oil demand caused by lower U.S. consumption. In the absence of a rightward shift in supply, therefore, world oil consumption cannot remain higher with a tariff.

U.S. exports and economic activity are not being dampened by a worldwide recession, as happens during an oil disruption.

## CONCLUSIONS

Both oil tariffs and oil disruptions can have negative impacts on the GNP of an oil-importing economy. However, it appears unlikely that the impacts of a tariff would be as catastrophic as the DOE analysis implied. The distinction between permanent and temporary reductions in real GNP appears to be critical, but there is also a need to evaluate critically the oil-GNP relationship in light of the declining importance of oil in the economy. This paper offers an alternative to the DOE loss function, which while remaining simple in the tradition of the DOE analysis, captures the dynamic elements of the response. Moreover, there may be more opportunity to lessen these losses by using accommodating policy or by phasing in the oil price increase. As a result, the argument against the oil import tariff should not depend so critically upon the impact on GNP.

There may be other concerns with a tariff, however. As one proponent of a tariff (Hogan, 1987) admits, oil tariffs may not be separable from general trade policy and could encourage protectionist policies for other products. Moreover, the terms of trade effects of a tariff can become rather complex. Bruno and Sachs (1985) have emphasized that the savings decisions of oil producers have an important influence on world interest rates. Therefore, reductions in OPEC revenue through an oil import tariff can reduce world savings under certain circumstances, leading to higher real interest rates. This situation could hurt a net-debtor country like the United States.

Additional thought should also be directed towards the source of the benefits derived from a tariff. Do we want simply to reduce oil imports or to minimize our exposure to fluctuating oil prices?

Policies like an oil tariff are constructed primarily to provide terms-of-trade or oil wealth benefits during stable markets or to reduce such losses during a disruption.[14] These losses appear to be related directly to the change in oil price and the level of oil *imports*. While they may also reduce the temporary output and employment losses, there may be other policies that can do so more directly and effectively.

The gains from insulating the economy from reductions in output, or real GNP as conventionally measured, appear to be more a function of the change in oil prices and the level of oil *consumption*, as well as other factors such as the degree of price rigidity within the economy. Each barrel reduction

14. This is the issue addressed by the optimal tariff literature in international trade, upon which the oil import tariff argument is based.

in oil use helps to insulate the economy from the transitory impact of oil price increases. It makes little difference whether that barrel is imported or produced domestically.[15] Reductions in real GNP accounted for about 70 percent of the total economic losses from a disruption in the EMF study. Industrialized economies, therefore, should find those policies that provide protection from extreme fluctuations in oil prices more valuable for energy security purposes than those geared for reducing the level of oil imports, *ceteris paribus*.[16] Oil stockpiles are particularly attractive beause their release during a disruption tends to reduce both oil prices and oil imports.

A policy that introduces greater price flexibility or that reduces nonenergy costs during a shock can be a particularly valuable option that provides many of the security benefits attributed to a tariff. For example, Solow [9] has suggested the value of flexible general excise taxes that could be reduced at the time of a disruption. Such a tax would not directly affect oil imports but would help to reduce the pressure for increased production costs during a shock by lowering the non-energy costs of firms. The United States currently has no federal excise tax that could be used for this purpose, but general consumption taxes, advocated by some, could be used in this way. It would appear that such policies provide more direct relief from the significant losses in output and employment than would an oil import tariff.

## APPENDIX

### U.S. Oil Prices in the DOE Scenarios

The DOE study developed a set of scenarios to evaluate different oil import tariffs under alternative oil market conditions showing a lower and higher world oil price path. Table A.1 shows the U.S. oil prices between 1988 and 1995 with and without a $10 per barrel tariff in the lower oil price case. Initially more than $9 of the tariff is passed through to U.S. consumers. Over time, however, the tariff's incidence on U.S. consumers declines until only $6 per barrel is passed through by 1994, the year before the hypothetical disruption. Real U.S. prices with the tariff rise more slowly than without the tariff and actually decline during the first few years.

15. This result appears to be true for many of the Keynesian models represented in EMF (1987) as well as for those with more neoclassical roots, such as the Mork model. The rise in the aggregate price level, which triggers the reduction in real output, depends upon oil's relative importance in the economy, whether it is domestically produced or imported.

16. Thus, direct subsidies to domestic production for reducing imports are not only economically inefficient but also have limited value in energy security terms.

**Table A.1. U.S. Oil Prices With and Without a $10 per Barrel Tariff: DOE Lower World Oil Price Path (1985 $ per Barrel)**

| Year | Without Tariff | With Tariff |
|---|---|---|
| 1988 | 14.49 | 23.63 |
| 1989 | 15.00 | 23.25 |
| 1990 | 15.49 | 23.03 |
| 1991 | 16.69 | 23.57 |
| 1992 | 17.90 | 24.20 |
| 1993 | 19.10 | 25.20 |
| 1994 | 20.31 | 26.41 |
| 1995 | 70.00 | 66.90 |

*Source:* U.S. Department of Energy (1987), Appendix D.

## Parameters for the Combined Loss Function

(4) calls for two parameters to represent the annual decline in potential output ($a$) and the four-year cumulative losses in capacity utilization ($b$). For the reasons discussed in the text, the GNP impacts were expressed as GNP reductions per dollar per barrel increase in the oil price.

The DRI tariff analysis [11] reported GNP reductions of $7.0, $28.0, $52.0, and $51.0 billion (1982$) from a $5 per barrel increase in U.S. oil prices due to a tariff. The present value (at 10 percent) of the cumulative loss in real GNP over this four-year period equals $126 billion, in 1985$. Based upon discussions with those familar with the model, $38 billion of these losses were attributed to reductions in potential output, with the remaining $88 billion treated as adjustment losses. Thus, on a per dollar-per-barrel basis, we set $a = (38/5)/4 = 1.9$ and $b = (88/5) = 17.6$.

The GNP losses behind the results from the EMF study are discussed in the next section. The resulting parameters ($a$, $b$) are: Data Resources (1,10) and Hickman-Coen (0.5,9).

The two GNP impacts from the DRI model are very similar to each other when expressed as the percent loss for each one percent increase in the oil price. For example, the recent tariff analysis [11] shows that at its peak loss, real GNP is 1.3 percent lower when U.S. oil prices are 27 percent higher due to a $5 tariff. In DRI results reported in the Energy Modeling Forum [4] model comparison several years ago, the peak GNP loss was 0.96 percent for a 20 percent international oil price shock. The implied elasticity between real GNP and oil prices is the same $-0.048$, although the dynamic pattern is somewhat different with the more recent analysis showing smaller immediate impacts. The similarity between the GNP impacts of a tariff, absent any specific specific recycling mechanisms, and an external oil shock of comparable size is consistent with the view, expressed in EMF (1987), that GNP is lost more through price shocks than through income transfers. However, the two shocks can have very different effects on the U.S.'s real income through their effect on the nation's international terms of trade.

The similarity between the proportional GNP effects (standardized for the percent change in oil prices) suggests a fair degree of stability in the estimated coefficients governing the oil-GNP relationship in the DRI model. The decline in actual GNP will depend importantly upon the effect on the general price level, which influences aggregate demand. The price equations in this model are estimated in percent change form, so that there are estimated coefficients linking the percent change in the prices of intermediate and final goods to the percent change in oil and other energy prices. In addition, potential output is estimated as a Cobb-Douglas function of energy as well as other inputs. This specification assumes a constant value share for energy, which also helps to govern the proportional response of potential output to energy prices. While these specifications may well provide the best fit to the historical experience, the assumption of constant elasticities may be inappropriate for projections under special circumstances, particularly when real oil prices and oil's relative importance in the economy have fallen sharply. Although we do not know whether a bias exists, it would appear imprudent to totally ignore this caveat. This concern explains why we have supplemented the recent DRI tariff analysis with the estimates from the EMF study, expressing all impacts on a per-barrel basis rather than as elasticities.

## GNP Losses in the EMF Study

The EMF study compared the responses of 13 U.S. macroeconomic models and one Canadian model to oil price shocks and to policies that might be used to mitigate the impacts of such shocks. While the study simulated shocks and policies over the 1983–86 period, much that was learned during the study is applicable in some form to the kinds of taxes and shocks considered in the DOE study.

Several conclusions of that study should be particularly emphasized:

1. There was considerably more consensus among the models on the impacts of an oil shock than on the responses to traditional macroeconomic policies such as monetary policy or income tax reductions.
2. The estimates of the impact of oil price shocks on the economy were standardized across models by assuming that the government adopts a passive or neutral role, without changing tax rates or altering the money supply.
3. The economy suffered its severest losses during the second year after the shock—about twice the losses incurred during the first year. Thereafter, the GNP losses became smaller in the third and fourth year.

**Table A.2: GNP Losses in 20% Oil Shock Case (Billions of 1972 Dollars)**

| | *Data Resources Losses* | | | *Hickman-Coen Losses* | | |
|---|---|---|---|---|---|---|
| *Year* | *Actual* | *Potential* | *Adjustment* | *Actual* | *Potential* | *Adjustment* |
| 1 | 8.6 | 1.8 | 6.8 | 7.5 | (0.2) | 7.7 |
| 2 | 15.1 | 3.9 | 11.2 | 15.0 | 1.6 | 13.4 |
| 3 | 17.0 | 5.5 | 11.5 | 12.3 | 3.2 | 9.1 |
| 4 | 16.5 | 6.7 | 9.8 | 7.0 | 3.6 | 3.4 |
| Net Present Value | 48.8 | 14.9 | 33.8 | 36.6 | 6.6 | 30.0 |
| GNP Loss[a] per $1 increase | 15.1 | 4.6 | 10.5 | 11.3 | 2.0 | 9.3 |

[a] Billions of 1985 dollars

*Source*: Energy Modeling Forum (1987).

4. The cumulative losses from an oil shock over a four-year period were substantial. The EMF estimated that about 70 percent of total economic losses were reductions in real GNP (vs. declines in the terms of trade) and that about 20–30 percent of these GNP losses were permanent declines in potential output, while the remainder were declines due to adjustment losses.
5. The effects of an internal energy shock (e.g., a tax) on real GNP appear comparable to those of an external oil shock of comparable size. However, the two shocks can have very different effects on the U.S.'s wealth or international terms of trade.
6. Given the same baseline conditions, the GNP impacts of an energy price increase appear to be proportional to the size of the shock.

The EMF study compared the actual (measured) GNP responses in fourteen macroeconomic models resulting from a permanent oil price shock of several different magnitudes. Table A.2 disaggregates the responses for two models to a 20 percent oil shock into declines in potential output and declines in actual output that exceeded the reductions in potential output. For this analysis, we consider the second component—columns 3 and 6—as representing the temporary adjustment loss of an oil price shock. The net present value of these losses are reported in 1972 dollars, which was the base year for the models at the time of the study. In the last row, we have expressed these impacts as lost GNP per dollar increase in oil price, after converting both the GNP loss and oil price change ($7.20 per barrel) to 1985 values, which were used in the DOE study.

DRI estimates are representative of the median results for the study. The Hickman-Coen results offer an interesting contrast in that potential output losses comprise a smaller proportion of the total GNP decline and that the adjustment losses beging to move sharply towards zero after the second year.

The permanent output response was computed as simply the average of the potential output losses for the four years in net present value terms. It shows the reduction in potential GNP each year. The temporary output response was equated to the cumulative four-year adjustment losses in present value terms. It essentially aggregates four years of GNP losses and assumes they they all occur in the year of the shock. Thus, for every dollar increase in oil price, output is permamently reduced by $1 billion and temporarily reduced by $10 billion when the loss function is calibrated to the DRI results. These responses become $0.5 billion and $9 billion, respectively, when the Hickman-Coen results are used.

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