No. 8912

A DYNAMIC COMPARISON OF AN OIL TARIFF, A PRODUCER SUBSIDY, AND A GASOLINE TAX

by
Mine Yucel*
Federal Reserve Bank of Dallas
and
Carol Dahl*
Louisiana State University

August 1989

Research Paper

Federal Reserve Bank of Dallas

No. 8912

A DYNAMIC COMPARISON OF AN OIL TARIFF, A PRODUCER SUBSIDY, AND A GASOLINE TAX

by
Mine Yucel*
Federal Reserve Bank of Dallas
and
Carol Dahl*
Louisiana State University

August 1989

*The views expressed in this article are solely those of the authors and should not be attributed to the Federal Reserve Bank of Dallas, the Federal Reserve System, or Louisiana State University.

A Dynamic Comparison of an Oil Tariff, a Producer Subsidy, and a Gasoline Tax

by

Mine Yücel
Senior Economist
Federal Reserve Bank of Dallas
Station K
Dallas, TX 75222

and

Carol Dahl
Associate Professor of Economics
Department of Economics
Louisiana State University
Baton Rouge, LA 70803

August 1989

ABSTRACT Recent increases in oil imports have spawned a variety of suggestions aimed at protecting the domestic oil industry. If implemented, these policies including an oil tariff, a domestic producer subsidy, and a gasoline tax, would result in income transfers involving billions of dollars. Since they would have immediate as well as long term implications which might differ within and across policies, we provide policy makers with a qualitative comparison of these polices using a dynamic optimal control model. Fifty year price and output paths for OPEC and the U.S. are simulated assuming that U.S. producers are competitive and OPEC is a dominant firm, maximizing its profits, taking U.S. output as given. We then compare the effects of these policies on U.S. vulnerability and security, macroeconomic activity, the federal government budget deficit, and welfare issues.

Low oil prices in recent years have benefited consumers and the downstream refining industry but have wrought havoc with high cost domestic producers and their support industries. Falling domestic production and increasing imports are projected to continue, causing concern over dependence on foreign oil supplies and security issues.[1] Since these trends have renewed suggestions to protect the domestic oil market, we will compare some of these suggestions - an oil import fee, increased gasoline taxes, and subsidies to domestic oil and gas producers.[2]

Such protectionist policies have been appealed to on a number of grounds. Security arguments center around the percent of imported oil and the macroeconomic effects of disrupting these imports. Tariffs and oil product taxes have federal deficit reduction appeal, as well. Shifting the tax onto foreign oil suppliers or exercising monopsony power through taxation has also

---

[1] US oil production (8971 thousand b/d in 1985 and 8115 thousand b/d in 1988) is projected to be 7100 thousandb/d in 1993. Crude oil imports (3201 thousand b/d in 1985 and 5329 thousand b/d in 1988) are projected to increase to 7545 in 1993. Sources: 1985 - Basic Petroleum Data Book, 1986 & Oil and Gas Journal, 11-14-88:78.

[2] For example, President Bush in his campaign suggested subsidies to domestic producers. Rostenkowski recommends a 10-15 cent per gallon increase in the current 9 cent excise tax on gasoline. Oil and Gas Journal 12/12/88:3. Alan Greenspan argues that "... a gasoline tax would do 'less harm' than other levies." Wall Street Journal, 2/3/89:2.

been considered.

Broadman (1986) argues for a domestic oil premium. The two parts of this premium, the long term effects of changes in import demand on the world price and the external costs of oil supply disruption as related to changes in oil use, are found to range from $2.00 to $124.00 and are quite sensitive to the assumptions made about the market.Broadman and Hogan (1988) using static analysis and including a security component and macroeconomic effects find an optimal tariff around $10 per barrel.

Studies of revenue consider tax efficiency. Bizer and Stewart (1987) using a small general equilibrium open economy model conclude that a tax on labor income dominates both an oil consumption tax and a tariff in terms of the dollar cost of additional revenue. The tariff is particularly costly, especially if the rest of the world retaliates. Schmidt and Dunstan (1985) using the MIT-Penn-SSRC economic model find that a $5.00 tariff would be shifted to final consumers and would generate higher inflation and unemployment than an equal revenue income tax.

Dynamic analysis of these issues has included both analytical work and simulations.Bergstrom (1982) considers the revenue aspects of an oil tariff by analytically working out the static and dynamic optimal oil tariff in an n-country pure trade Nash equilibrium model with total oil supplies fixed and costlessly extracted.He concludes that the optimal tax might be on the order of $10.50 to $21 per barrel.

Dynamic analysis with costs in the model can not be solved analytically. Thus, Nesbitt and Choi (1988) using the DFI World Oil Model dynamically simulate a U.S. tariff over a 60 year time horizon. In their model with seven supply and five demand regions, OPEC is divided into the core cartel and the competitive fringe. Oil resources are a function of future additions to proved reserves and backstop fuels are $60 per barrel. They conclude that OPEC absorbs only a small share of a $10.50 per barrel tariff and find large losses in net economic welfare. From the above studies we can distill a variety of issues to consider in comparing the three suggested policies - 1. U.S. vulnerability, represented by amount of reserves and the share of oil imports; 2. Macroeconomic effects, represented by the increased price of oil and any accompanying income effects; 3. The effect of the policy on the U.S. Federal deficit; and 4. The amount of tax that can be shifted, affecting total welfare in the oil market and the efficiency of the tax. We can distill a variety of approaches, as well, including static partial equilibrium, static general equilibrium with production, static and dynamic general equilibrium pure trade models, and a partial equilibrium dynamic model with production.

In choosing from these approaches, vulnerability issues clearly make dynamic considerations central to the analysis. Policies which reduce current oil imports and stimulate domestic production will increase our future vulnerability, if we go to the well and find it dry. Moreover, theory supports the choice of dynamically modeling optimal production decisions for a nonrenewable natural resource.

The effects of tariffs, domestic subsidies, and gasoline taxes will depend on the costs of both OPEC and domestic producers, which are rather dissimilar and will change as reserves are depleted. However, the explicit inclusion of these costs renders an analytical solution unobtainable. Thus, we abandon the analytical attractiveness of Bergstrom (1982) in favor the more computationally complex dynamic optimal control model.

Given the concentration of reserves in OPEC countries[3] and in the interest of keeping the model reproducible and relatively transparent, we focus our analysis on OPEC and U.S. domestic producers. Our choice of market structure is based on recent work by Griffin (1985).[4] Testing between 4 static econometric models that represent a cartel, competition, target revenues, and property rights, his results tend to favor a market sharing cartel model for OPEC. Testing between a cartel and competitive model, his results tend to favor the competitive model for non-OPEC producers. These assumptions and our model are more formally developed below.

MODEL

In the model OPEC is a dominant firm facing U.S. total demand for oil minus U.S. domestic production and non-OPEC U.S. imports. Domestic producers are taken to be profit maximizing price takers on the U.S. crude oil market while non-OPEC oil suppliers are assumed to supply a constant amount to the U.S.. Both the U.S. and OPEC own oil reserves and maximize their profits over a given time horizon T. We simulate the problem for a base case as well as an oil tariff of τ, a gasoline tax of δ, and a subsidy to U.S. producers of σ, assuming no retaliation. The general maximization problem for the U.S. is to choose the production path of Qu that maximizes:

---

[3] OPEC has 75% of global oil reserves and 82% of noncommunist oil reserves (Oil and Gas Journal 12/26/88:43) and is expected to garner an increasing share of the export market in the 21st century.

[4] OPEC market structure and control has been the subject of considerable debate. For summaries of the literature and bibliographic references see Gately (1984) and Dahl and Yücel (1988).

$$\text{Max} \int_0^T [P - \beta\delta + \sigma - Cu(Ru)]Qu\ e^{-rt} \tag{1a}$$

subject to the constraint

$$\dot{R}u = -Qu \tag{1b}$$

while OPEC chooses the production path for Qo that maximizes

$$\int_0^T [f(Qu,Qo)(1-\tau) - \beta\delta - Co(Ro)]Qo\ e^{-rt} \tag{2a}$$

subject to

$$\dot{R}o = -Qo\,. \tag{2b}$$

In the above expressions, P is the price of oil, β is the percent of the barrel going to gasoline, f is the inverted demand function for domestic and OPEC oil by U.S. consumers, Qo is OPEC production going to U.S. markets, Qu is U.S. domestic production, Ru and Ro are reserve levels, and r is the real interest rate. Cu and Co are average costs of production, the functional forms of which are developed in the next section.

The Hamiltonian for the U.S. is

$$H = [P - \beta\delta + \sigma - Cu]Qu\ e^{-rt} + \mu_u(-Qu) \tag{3}$$

The first order conditions are

$$H_{Qu} = [(P - \beta\delta + \sigma) - Cu]e^{-rt} - \mu_u = 0 \tag{4}$$

$$\dot{\mu}_u = -H_{Ru} = C_{Ru}Qu\ e^{-rt} \tag{5}$$

Similarly, for OPEC we have

$$H = [f(Qu,Qo)(1-\tau) - \beta\delta - Co]Qo\ e^{-rt} + \mu_o(-Qo) \tag{6}$$

$$H_{Qo} = [(f_{Qo}Qo + f)(1-\tau) - \beta\delta - Co]e^{-rt} - \mu_o = 0 \tag{7}$$

$$\dot{\mu}_o = -H_{Ro} = C_{Ro}Qo\ e^{-rt} \tag{8}$$

The solution to the maximization problem above will need to satisfy the constraints (1b),(2b) and the optimality conditions (4),(5) and (7),(8). Since an analytical solution is not possible, this differential system is solved numerically using Miele's (1970, 1974) highly efficient Modified

Quasilinearization Algorithm. We construct performance indeces which measure the errors in the constraints and the optimality conditions and seek an iterative solution which will make these indeces smaller than a preselected convergence criterion. Our convergence criterion was 10^{-6}.

The model inputs are developed in the next section with simulation results given in the subsequent section.

MODEL INPUTS

To develop U.S. demand for domestic and OPEC oil we start with total U.S. demand for oil products:

$$Qt = Qu + Qo + Qn + Qp$$

Where Qt = the total demand for oil products in the U.S.. Qu, Qo, Qn, and Qp are the demand for products satisfied by domestic oil, OPEC oil, non-OPEC oil, and net product imports respectively. Qt is a constant elasticity function of demand price Pd and income Y or:[5]

$$Qt = \alpha\, Pd^{\beta} Y^{\pi}$$

To simplify the analysis and focus on the U.S. and OPEC, we assume that non-OPEC imports to the U.S. stay constant at their 1987 level (842.785 million barrels per year) over the simulation period :[6]

---

[5] We chose the constant elasticity functional form because it is by far the most popular functional form for econometric estimates of oil product demand. Good in sample fits have been obtained even over rather long estimation periods.

[6] The following oil exports measured in millions of tons and derived from median forecasts of an International Energy Workshop poll of 64 organizations (See Manne and Schrattenholzer (1989), suggest that holding non-OPEC imports into the U.S. constant is a reasonable upper bound. Imports of non U.S. OECD countries are expected to continually increase, suggesting they will not be likely to increase exports to the U.S. The Centrally Planned Economies (CPE) may be expected to increase exports somewhat in the near future, but in the longer term are expected to absorb more of their production

$$Qu + Qo + 842.785 + Qp = \alpha Pd^{\beta} Y^{\pi}$$

Since consumer welfare depends on the demand for oil products, we must first relate this demand to the derived demand for domestic and OPEC oil which is inputted into our simulation model. Product imports are assumed to be the same percent, ϕ, of U.S total demand as in 1987[7] and product demand price Pd is assumed to be the same percent, θ, of product supply price, P. Under these assumptions, U.S. demand for crude oil as a function of supply price of oil (P) is:

$$Qu + Qo + 842.785 = (1-\phi)\ \alpha(\theta P)^{\beta} Y^{\pi}$$

and price as a function of U.S. and OPEC production is:

$$P = (1/\phi)[1/((1-\phi)\alpha)(Qu + Qo + 842.785)]^{1/\beta}\ Y^{-\pi/\beta}$$

There are a number of estimates of price and income elasticity for crude oil and an even larger number of estimate of elasticities for various petroleum products. From these, we choose base case price and income elasticities of -.9 and .8, which are normalized around 1987 variable values giving an inverted demand function of:[8]

---

themselves. The non-OPEC developing countries, although net exporters now, are expected to be net importers by 2000. Thus, OPEC is the only area of the world expected to have any significant increase in export capacity.

Net Oil Exports	1985	1990	2000	2010
CPE	94	115.45	97	90.5
Non-US OECD	-577.5	-640	-635	-659
OPEC	699	858.4	1165	1190
Other Mkt.	7	21.5	-41.8	-26

[7] Product imports are needed to balance demands in various product markets and we assume this need for balance will continue. Current trends suggest that expectations of large OPEC product imports will not materialize as these products have tended to find other markets.

[8] For surveys of these elasticities see Bohi (1981), Bohi and Zimmerman (1984), and Dahl (1986). Many of the derived estimates for product price elasticity are between -.3 and -1.6, while many of those for income elasticity are between .6 and 1.4. We have experimented with price

$$P = 136.83\ (Qu + Qo + 842.785)^{-1.1} Y^{.89}$$

Moving on to the supply side of the market, we start with OPEC and U.S. estimated proved reserves as given in Table 1. Since this is clearly a lower bound on total reserves available over the simulation period and since OPEC reserves have recently been estimated to be 50 to 90 percent more than current levels, we increase them 50% for our base case simulations. Production costs were available for one year for Aramco for Saudi Arabia. They were derived for the U.S. by distributing total production costs over oil and gas by energy content. Costs for the other OPEC members were extrapolated from U.S. and Saudi numbers based on production per well, all given in Table 1. These production costs were used to develop the following cost function for OPEC:

$$Co = 20.043 - .00002\ Ro$$

The slope of this function was derived from a regression of the above costs on reserves and the intercept was arrived at by normalizing around the average of the above OPEC production costs and total OPEC reserves. The U.S. cost function, developed as in Pindyck (1978), is:

$$Cu = K/Ru = 137721.5/Ru$$

With K chosen by normalizing around the production costs and reserves given in Table 1. Last, we assume income grows at 2.5% per year and the real interest rate is 5%.[9]

---

elasticities ranging from -.7 to -1.1. The 1987 values are normalized around 1987 product demand minus net product imports of 5.624 billion barrels, GDP of $4.461 trillion, and an oil supply price of $16.35.

[9] We have chosen the same discount rate for OPEC and the U.S. since there is conflicting evidence in the literature whether OPEC might have a higher or lower rate of discount than the U.S. Earlier work using property rights arguments such as Mead (1979) and Johany (1980) suggest that their discount rate should be lower than those for oil companies. More recent work by Adelman (1986) suggests that OPEC's discount rate should be higher.

RESULTS

We begin by presenting and briefly discussing simulated optimal time paths for U.S. production, OPEC production, and oil prices for a base case with no tariff or subsidy, and the current gasoline tax of 9 cents per gallon (τ, σ, and $\delta = 0$). These paths are the bases for the policy evaluations.(These base case paths are given in Figure 1. End point values for all prices and outputs are given in Table 2.)

Policies are then implemented one at a time and new price and output paths are computed. We present and discuss complete simulation results for each of our representative policies: $\tau = 25\%$, $\sigma = \$5$ per barrel, $\delta = \$.25$ per gallon. These policies are roughly comparable since the 25% import fee corresponds to an initial tariff of $5.00, while the gasoline tax can be translated into a tax on oil at roughly $5.00 per barrel. Although numerous cases were done for each policy, in the interest of clarity and brevity, we only discuss interesting implications from this sensitivity analysis conducted across various rates and parameters.[10] (Time paths for these representative policies are given in Figures 2-4. For improved resolution, they are expressed as ratios to the base case).

For the base case, simulated U.S. production is lower than actual 1987 production, OPEC production is higher, oil prices lightly higher, and total U.S. demand lower. (See Table 2.) U.S simulated production begins at 35% but falls to only 7% of OPEC production over the simulation period. It declines fairly steeply during the 50 year time horizon to around 19% of its initial

[10] Complete results of all simulations are available upon request from the authors.

level, whereas OPEC production is more stable with a very flat convex shape.[11] Final OPEC production is 92% of its initial level resulting from OPEC's very high level of reserves coupled with relatively low and stable production costs. Initial simulated price is $20.18 rising an average of 2.7% per year to$80.86.

The tariff increases U.S. consumer prices and decreases OPEC output throughout the simulation period. As can be seen in Figure 1, the increase in prices in the final years are greater than those in the early years. This price path, which leads to higher U.S production in the early years and lower production in later years, results in an earlier depletion of the resource and subsequently higher production costs. These effects are more pronounced, the higher the tariff. The tariff has the highest price path of all the policies.

The U.S. producer subsidy increases initial production,lowers initial prices, and raises final prices. The higher the subsidy, the lower the initial price and the higher the initial production. Therefore, with a subsidy both producers and consumers are better off in the early years. Interestingly enough, OPEC production is also increased with the subsidy in the early years. Increased relative U.S. production in the early years reduces OPEC's market share, increases their demand elasticity and, hence, results in increased production. As can be seen from Figure 2, the subsidy has the highest U.S.production of all policies in the early years, however the reverse is true in the future.

The gasoline tax increases consumer prices more than it decreases producer prices and causes the least price variation from the base case among the three policies. The tax effects on the two production profiles are

---

11 The convex shape results from the growth in demand.

somewhat different, as can be seen in Figures 2 and 3. OPEC production, which is lower over the whole period, falls relatively more in the earlier part of the period converging towards the base case in the later part. Thus, as the tax becomes a smaller percent of supply price and its discounted value is less, OPEC alters its production profile less. The U.S. pattern is rather more interesting. Static analysis would suggest that U.S. production should fall as well. In a dynamic setting, the tax causes U.S. production to be postponed into the future, and thus, U.S. production only falls in the early period.

These protectionist policies have long term implications on U.S. vulnerability and security, macroeconomic activity, the federal government budget deficit, and welfare issues. We proceed by briefly touching on these effects across policies.(Simulated numerical values are given in Table 3 for comparison purposes and to provide information on orders of magnitude.)

Vulnerability and security are measured by reserves left in the ground at the end of 50 years and the share of imported oil. Relative to the base case, the tariff leaves 8.1% less, the subsidy 7.7% less, and the gasoline tax over 0.1% more reserves after 50 years. The increase in the amount of reserves left in the ground with the gasoline tax is small because the tax shifts production from the present to the future.

All policies lower the initial share of imports from the base case.The tariff and gasoline tax lower shares over the whole period with the gasoline tax having a somewhat larger effect in the early period but converging to that for the tariff as OPEC's share continues to increase. The subsidy is the only policy that raises future vulnerability by increasing the import share after 2002. However, one can see from Table 3 that by the end of the simulation period the differences are rather modest.

In terms of overall long term security, it would seem that the gasoline tax would be best. It leaves more reserves in the ground and has the lowest share for OPEC in all years. The subsidy, although enhancing security early on, would be costly later. It would leave only slightly more reserves in the ground than the tariff, which lowered import shares over the entire period.

These policies also have important implications on producer welfare, calculated as changes in profits, and on consumer welfare, calculated as changes in consumer surplus using Hausman's (1981) measure of compensated variation. Discounted present values of these measures, all given in Table 3, determine deadweight losses or gains in total welfare in the oil market for each policy. To be able to compare the different policies, we express the losses or gains in welfare as a percentage of total revenues from the tariff or the tax. For the subsidy, the welfare gains are calculated by adding the gains in producer and consumer surplus minus the subsidy paid by the government. This net gain (or loss) is then expressed as a percentage of the total subsidy.

In terms of total welfare, the tariff is best. Since OPEC absorbs a large share of the tariff (OPEC profits fall 29.2%),the tariff turns out to be welfare enhancing for the U.S.. The welfare gains are 21.2 cents per dollar of revenue generated. The increase in U.S. profits (11.8%) plus the tariff revenues outweigh the losses in consumer surplus. These gains in welfare diminish as we approach the welfare neutral rate which is between 50 and 55%.

The subsidy turns out to be welfare enhancing as well. U.S. consumers are better off due to the decrease in prices and U.S. profits increase by 22.4%. The welfare gain (the increases in consumer and producer surplus minus the total subsidy) is 23.6 cents per dollar of subsidy. These gains however, are similar to those of the tariff's and diminish as we approach the welfare neutral rate of around $11 per barrel. This would be OPEC's preferred policy as well, as profits fall by only 0.5%.

The gasoline tax scores the lowest in terms of welfare. The welfare loss is $1.26 per dollar of revenue generated. U.S. producer profits fall by 2.5%. Although foreign suppliers of oil bear some of the burden of the tax, (OPEC profits fall by 15.3%), the increase in the gasoline tax is still costly for the U.S.

CONCLUSIONS

Feelings of insecurity engendered by rising oil imports have increased U.S. protectionist sentiments towards the domestic oil industry. Since there are long term implications of these policies, we compare the effects of an oil tariff, a subsidy to U.S. oil producers, and an increase in the gasoline tax using an optimal control framework. U.S. producers are modeled as competitive while OPEC is considered a dominant firm, maximizing its profits taking U.S. output as given. The simulations suggest the highest U.S. producer prices for a tariff, while consumer prices tend to be highest over much of the period for the gasoline tax. U.S. production is highest in the early years with the subsidy and highest in the later years with the gasoline tax. OPEC's production path is highest with the subsidy.

These simulated prices and output paths have long term policy implications relating to U.S. vulnerability and security, and welfare issues. They show that there is a tradeoff between the issues of vulnerability and security, and welfare. The gasoline tax which enhances security and lessens U.S. vulnerability to future oil disruptions is also the most welfare costly policy. The subsidy, the preferred policy of OPEC, is welfare enhancing but clearly makes us more dependent on foreign oil in the future. From a welfare point of view, the tariff is best. It is also the policy which raises the most revenues for the government. Surprisingly, the simulations suggest that based on the criteria included in our analysis, the ad valorem tariff assuming no retaliation might be the best choice over the simulation period. Although it causes higher depletion, it did not lower the U.S.'s share in the market over the simulation period.

References

Adelman, M.A. (1986) "Oil Producing Countries' Discount Rates," Resources and Energy, 8:309-329.

Bergstrom, Theodore C. (1982) "On Capturing Oil Rents with a National Excise Tax," American Economic Review, 72(1), May: 194-201.

Bizer, David S. and Stuart, Charles (1987) "The Public Finance of a Protective Tariff: The Case of an Oil Import Fee" American Economic Review, 77(5), Dec.:1019-1023

Bohi, Douglas R. (1981). Analyzing Demand Behavior: A Study of Energy Elasticities, Published for Resources for the Future by Johns Hopkins Press, Baltimore, MD.

Bohi, Douglas R. and Zimmerman, Mary Beth (1984). "An Update on Econometric Studies of Energy Demand Behavior," Annual Energy Review, 9: 105-154.

Broadman, Harry G. (1986) "The Social Cost of Imported Oil" Energy Policy 14 (3): 242-252.

Broadman, Harry G. and Hogan, William W. (1988). "Is and Oil Tariff Justified? An American Debate: II. The Numbers Say Yes," Energy Journal. Vol. 9 (3): 7-29.

Dahl, Carol A. (1986). "Survey of Gasoline Demand." Energy Economics, 7(1), January, pp. 67-82.

Dahl, Carol and Yücel, Mine (1988) "OPEC Market Behavior," presented to The Southern Economic Association Annual Meeting, November, San Antonio, TX.

Gately, Dermot (1984). "A Ten-Year Retrospective: OPEC and the World Oil Market." Journal of Economic Literature XXII (September): 1100-1114.

Griffin, James M. (1985). "OPEC Behavior: A Test of Alternative Hypothesis." American Economic Review 75 (5): 954-963.

Hausman, Jerry A. (1981). "Exact Consumer's Surplus and Deadweight Loss," American Economic Review, 71 (4) Sept.: 662-676.

Hickman, B. G.; Huntington, H. G.; and Sweeney, J. L. (1987) Macroeconomic Impacts of Energy Shocks, New York, North Holland.

Johany, Ali (1980). The Myth of the OPEC Cartel, Wiley & Sons, New York, NY.

Manne, Alan S. and Schrattenholzer, L. (1989). "International Energy Workshop" Stanford University, Stanford, CA and The International Institute for Applied Systems Analysis, Laxenburg, Austria.

Mead, Walter (1979). "An Economic Analysis of Crude Oil Price Behavior in the 1970's," The Journal of Energy and Development, (Spring):212-228.

Miele, Angelo; Iyer, R. R.; and Wells, K. H. (1970). "Modified Quasilinearization and Optimal Initial Choice of Multipliers, Part 2, Optimal Control Problems," Journal of Optimization Theory and Applications, 6.

Miele, Angelo; Mangiavacchi, A.; and Aggarwal,A. K. (1974). "Modified Quasilinearization Algorithm for Optimal Control Problems with Nondifferential Constraints," Journal of Optimization Theory and Applications, 14 (5).

Nesbitt, Dale M. and Choi, Thomas Y. (1988). "Is and Oil Tariff Justified? An American Debate: II. The Numbers Say No," Energy Journal. Vol. 9 (3): 31-59.

Pindyck, Robert S. (1978). "The Optimal Exploration and Production of Nonrenewable Resources," Journal of Political Economy, 86 (5): 841-861.

Schmidt and Dunstan (1985) "Effects of Reducing the Deficit with and Oil Import Tariff" Federal Reserve Bank of Dallas Economic Review, Sept.:15-24.

Table 1: Variables representing OPEC's production capacity, costs and absorptive capacity

COUNTRY	Reserves	Production 1000 b/d	Production b/well	Production Costs
Libya	21000	1020.0	1543.12	4.37
UAE	96605	1361.0	2001.47	4.04
Algeria	8500	648.0	771.43	4.91
Ecuador	1615	157.0	170.28	5.34
Qatar	3150	284.0	1632.18	4.30
Iran	92850	2342.0	6487.53	0.87
SaudiArabia	166980	4054.0	6894.56	0.58
NeutralZone	5210	399.2	813.03	4.88
Indonesia	8400	1186.0	205.40	5.31
Kuwait	91920	1096.0	3019.28	3.32
Nigeria	15980	1239.0	988.83	4.76
Iraq	100000	2096.0	3408.13	3.05
Venezuela	56300	1592.0	162.50	5.34
Gabon	645	155.8	528.14	5.09
U.S.	25270	8276.7	13.00	5.45

Sources: Oil and Gas Journal, 12/28/87:36-37.
OPEC Annual Statistical Bulletin,
Cost - Authors computations, Basic Petroleum DataBook, Oil and Gas Journal 5/11/87:70

Units: Oil reserves are measured in millions of barrels, production costs in dollars per barrel, production is in 100 of barrels per day, while production per well measured in barrels.

Table 2: A Comparison of End Points Across Policies

	Producer Price		Consumer Price	
Year	1987	2037	1987	2037
Base Case	$20.18	$80.86	$46.34	$162.11
Tariff	$21.55	$88.02	$49.48	$176.51
Subsidy	$18.07	$82.57	$41.49	$166.91
Gasoline Tax	$19.91	$80.76	$57.73	$173.21

	U.S. Production		Opec Production	
Year	1987	2037	1987	2037
Base Case	1003	194	2807	2591
Tariff	1057	179	2487	2339
Subsidy	1381	157	2914	2559
Gasoline Tax	1004	202	1970	2387

Units: Prices in 1987 U.S. dollars per barrel.
Quantities are all in millions of barrels per year.

Table 3: Effects of a 25% Oil Tariff, a $5.00 per Barrel, and a $.25 per Gallon Gasoline Tax.

Effect on:	Base Case	Tariff	Subsidy	Gasoline Tax
U. S. Reserves 2037	1703	1564	1572	1705
OPEC's Share in 1987	73.7%	70.2%	67.8%	66.2%
OPEC's Share in 2037	93.0%	92.9%	94.2%	92.2%
Δ US Profits		5.3%	82.3%	-1.5%
Δ OPEC Profits		-73.9%	-11.2%	-63.3%
Δ Consumer Surplus		-84.1%	40.8%	-224.8%
Deadweight Losses (- = gain)		-21.2%	-23.6%	126.3%
Welfare Neutral Rate		50-55%	$11.00	None

Units: Values are for the whole period unless otherwise noted. Reserves are measured in millions of barrels. Δ US Profits, Δ Consumer Surplus, Deadweight losses and Δ OPEC profits are expressed as a percentage of the respective tax revenue or subsidy.

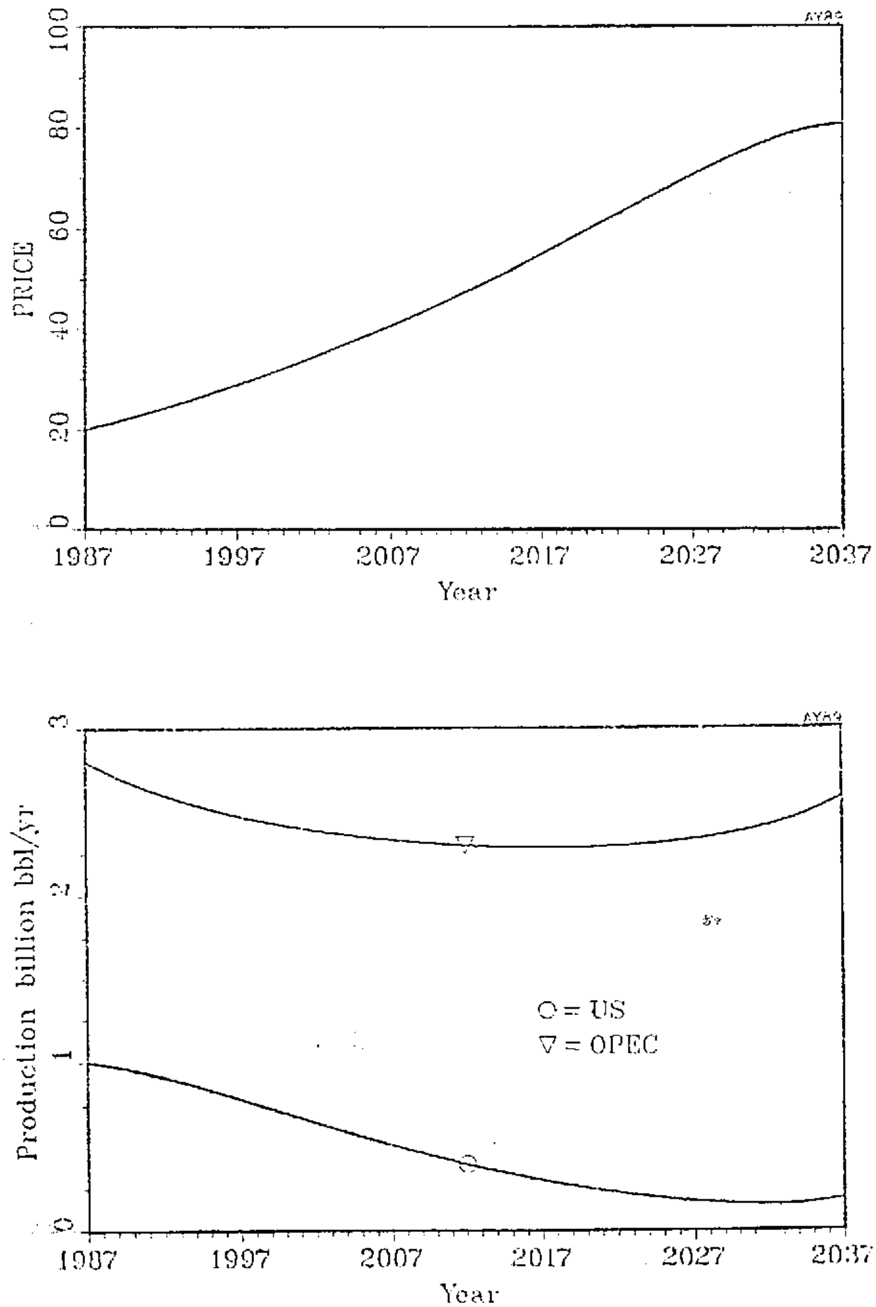

Figure 1. Price and Output Paths for the Base Case.

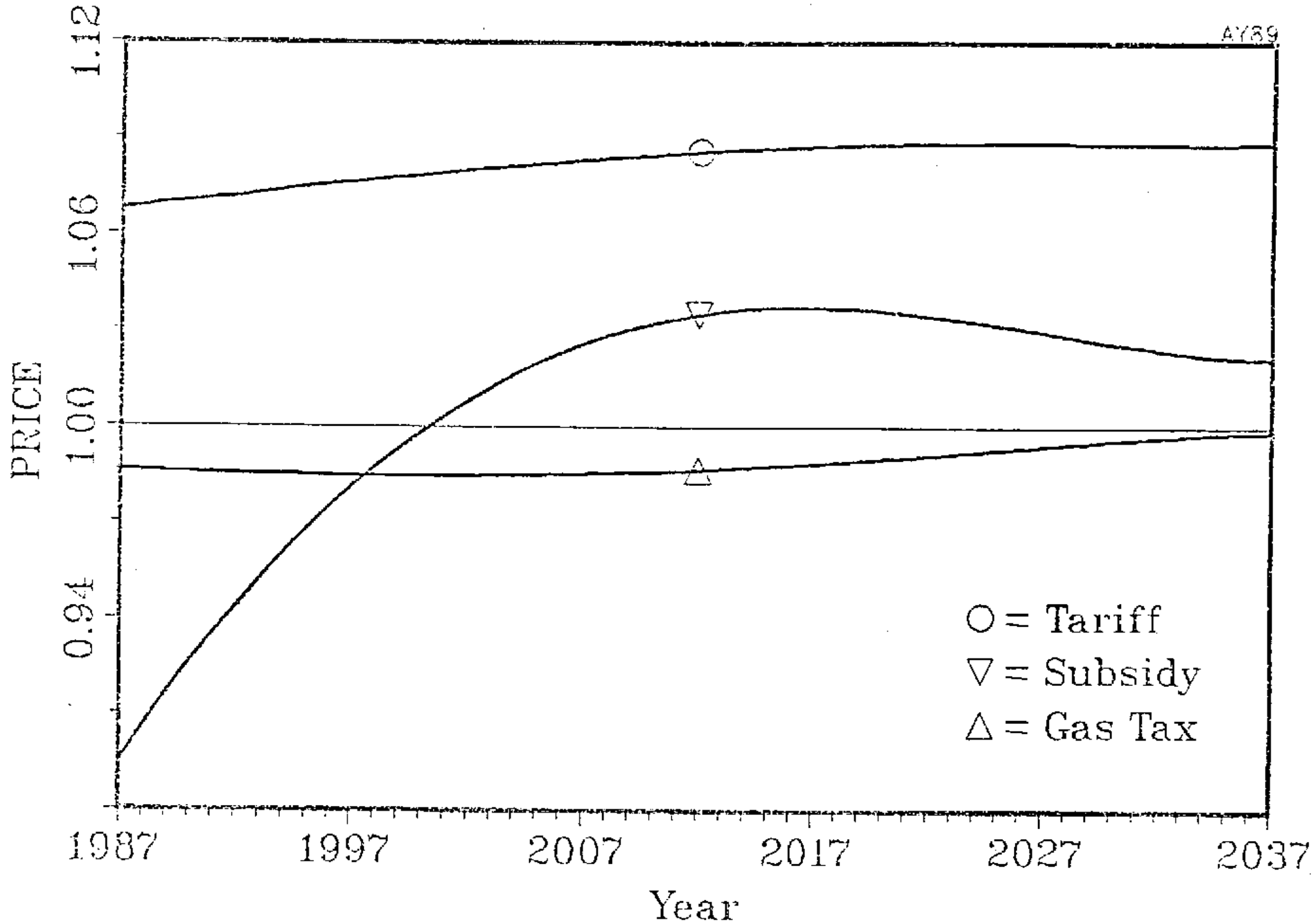

Figure 2. Prices (expressed as a ratio to the base case).

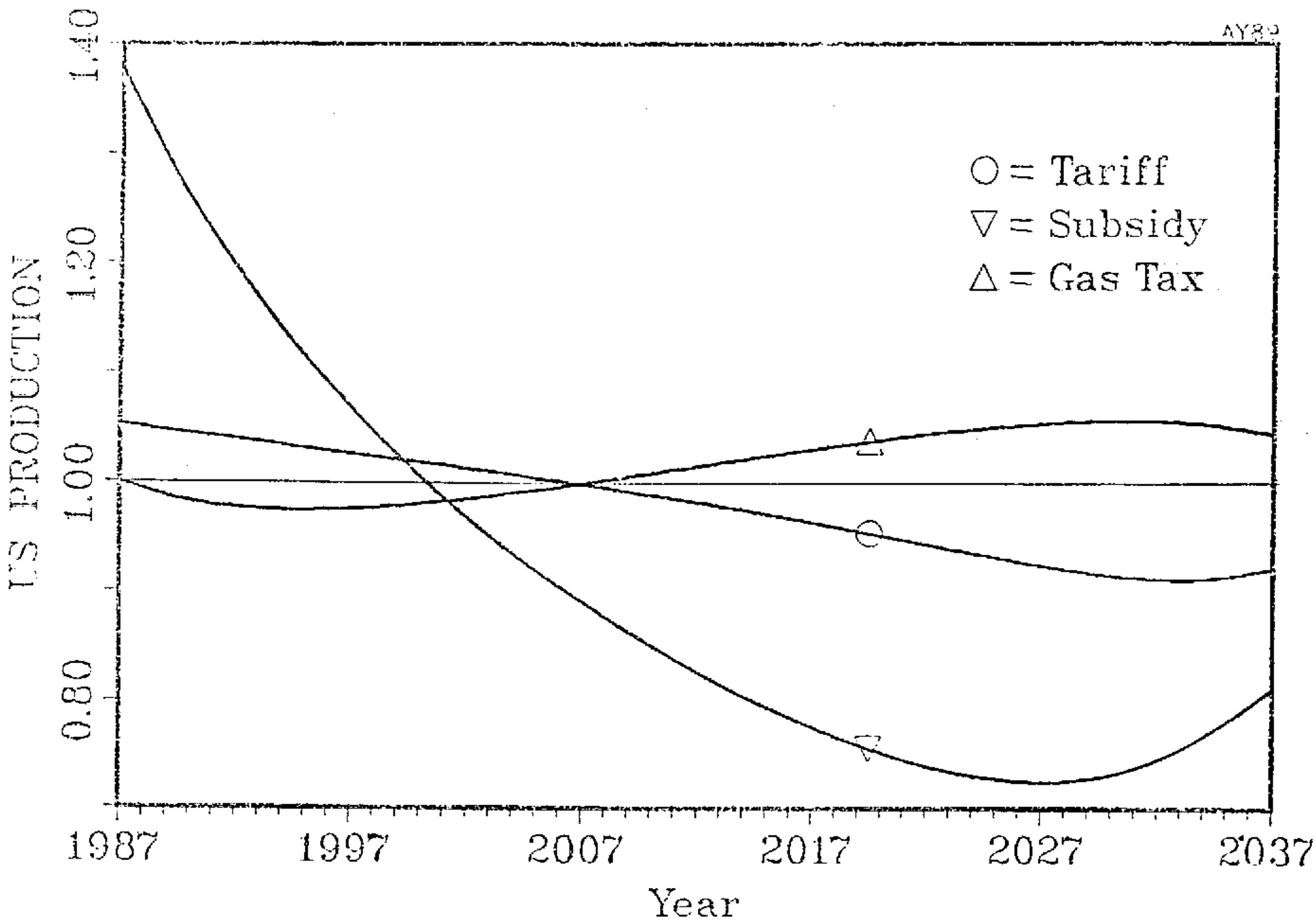

Figure 3. U.S. Production (expressed as a ratio to the base case).

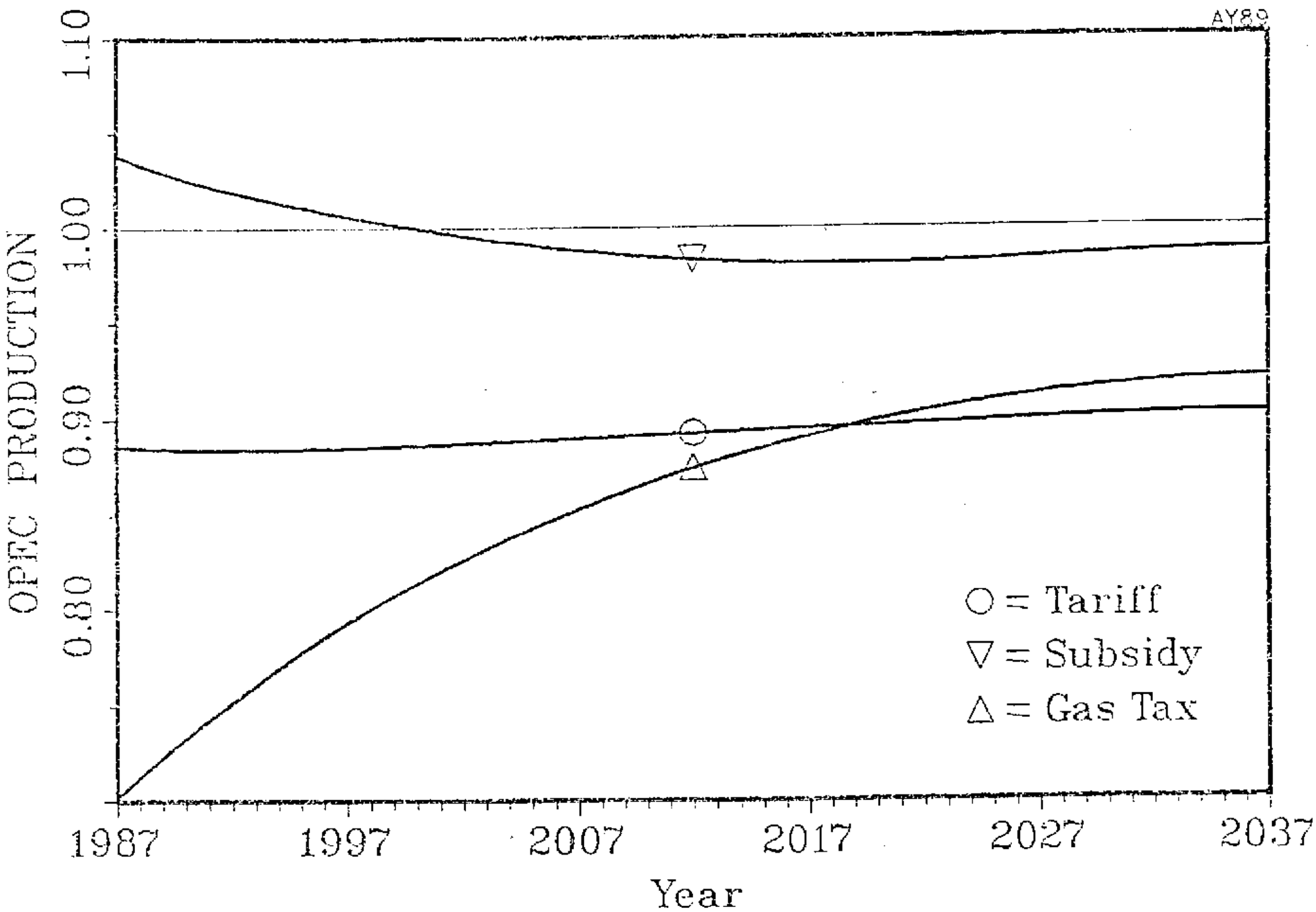

Figure 4. OPEC Production (expressed as a ratio to the base case).

RESEARCH PAPERS OF THE RESEARCH DEPARTMENT
FEDERAL RESERVE BANK OF DALLAS

Available, at no charge, from the Research Department
Federal Reserve Bank of Dallas, Station K
Dallas, Texas 75222

8801 Estimating the Impact of Monetary Policy on Short-Term Interest Rates in a Rational Expectations--Efficient Markets Model: Further Evidence (Kenneth J. Robinson and Eugenie D. Short)

8802 Exchange and Interest Rate Management and the International Transmission of Disturbances (W. Michael Cox and Douglas McTaggart)

8803 Theoretical Macroeconomic Modelling and Qualitative Specifications of the Bond Market (William R. Russell and Joseph H. Haslag)

8804 Augmented Information in a Theory of Ambiguity, Credibility and Inflation (Nathan Balke and Joseph H. Haslag)

8805 Investment and the Nominal Interest Rate The Variable Velocity Case (Evan F. Koenig)

8806 Tax Policy and Texas Economic Development (Stephen P.A. Brown)

8807 Unionization and Unemployment Rates: A Re-Examination of Olson's Labor Cartelization Hypothesis (William C. Gruben)

8808 The Development and Uses of Regional Indexes of Leading Economic Indicators (Keith R. Phillips)

8809 The Contribution of Nonhomothetic Preferences to Trade (Linda Hunter)

8810 Evidence on the Two Monetary Base Measures and Economic Activity (Joseph H. Haslag and Scott E. Hein)

8811 The Incidence of Sanctions Against U.S. Employers of Illegal Aliens (John K. Hill and James E. Pearce)

8901 An Econometric Analysis of U.S. Oil Demand (Stephen P.A. Brown and Keith R. Phillips)

8902 Further Evidence on the Liquidity Effect Using an Efficient-Markets Approach (Kenneth J. Robinson and Eugenie D. Short)

8903 Asymmetric Information and the Role of Fed Watching (Nathan Balke and Joseph H. Haslag)

8904 Federal Reserve System Reserve Requirements: 1959-88--A Note (Joseph H. Haslag and Scott E. Hein)

8905 Stock Returns and Inflation: Further Tests of the Proxy and Debt-Monetization Hypothesis (David Ely and Kenneth J. Robinson)