Working Papers in
AGRICULTURAL ECONOMICS

October 92 92-10

WORLD OIL: HOTELLING DEPLETION, OR ACCELERATING USE?

By Duane Chapman

Department of Agricultural Economics
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853-7801

WORLD OIL: HOTELLING DEPLETION, OR ACCELERATING USE?

By Duane Chapman*

October 1, 1992

---

* Professor of Resource Economics, Department of Agricultural Economics, Cornell University, Ithaca, NY 14853. An acknowledgement to W.G. Tomek, Dale Rothman, and Tom Drennen for comments, and Eleanor Smith and Joseph Baldwin for assistance.

CONTENTS

Abstract

In theoretical Hotelling-type models of resource depletion, oil use declines monotonically over time to depletion. However, world oil use has in fact been increasing for several years. Can theory and reality be reconciled? The answer is affirmative, if theory is modified to accommodate outward-shifting demand functions that are rising in response to growth in world population and income. Under this assumption, a Hotelling depletion model projects a 50-year period of increasing world oil use before the decline to exhaustion. This holds for both competitive and monopolistic regimes.

Hotelling theory has been criticized by Adelman and others, in part because of the unreality of the theoretical projections. By combining the modified Hotelling theory with U.S. Geological Survey resource estimates, the numerical projections seem congruent with Adelman's near term expectations.

Finally, a backstop technology such as renewable biomass ethanol introduces a new dimension. Assuming a $2 per gallon cost for the ethanol, the modified Hotelling theory projects accelerating use of conventional oil until depletion or substitution.

Consequently, it does not seem unreasonable to believe that a finite, limited resource of conventional oil is consistent with growing use for several decades. A projected exhaustion in 100 years is consistent with increasing use for 50 years.

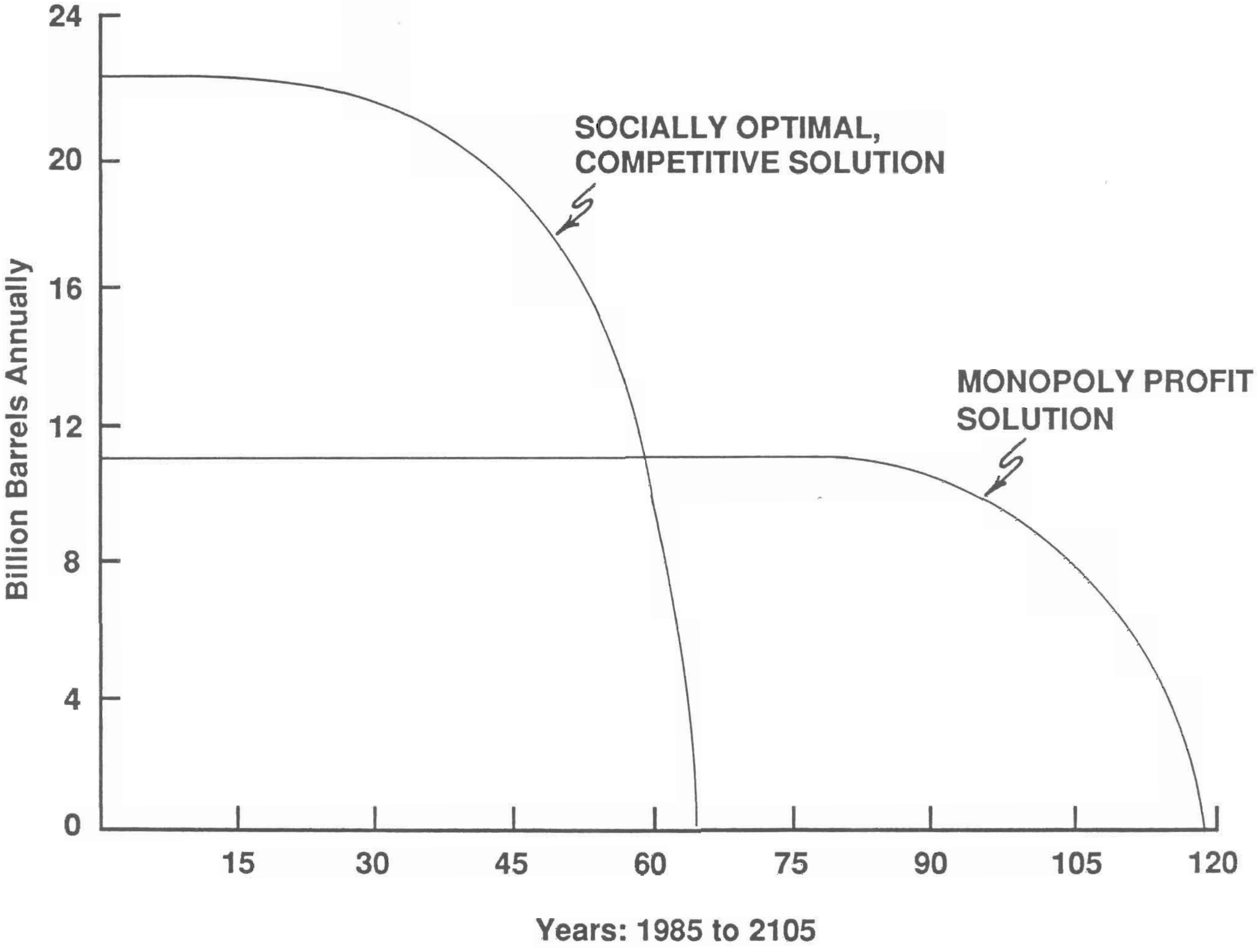
I. Adelman's Criticism

The exhaustibility of world oil resources has been debated since Hotelling's original 1931 article. Typically, a Hotelling model will show that the annual rate of oil use declines monotonically over time until exhaustion occurs. In the competitive version of the model, the rate of oil price increase over time is such that unit profit (also reflecting cost changes) rises at the same rate as real interest. The monopoly version has higher initial price, and lower initial rate of use. Consequently, the monopoly version has a longer period of use to exhaustion. The crossing, declining competition and monopoly curves in Figure 1 are basic theory (e.g. Stiglitz, Conrad and Clark). There are variations which incorporate technological change in extraction, backstop technology, and sequences of production from increasing cost reservoirs. The general Hotelling analysis, however, usually shows (under a given market regime) a declining rate of use to depletion.

The dominant criticism, represented by Adelman, argues persuasively that continuing low prices reflect the irrelevance of the Hotelling concept (Adelman 1989, 1990a,b, 1992; Watkins 1992). Adelman buttresses his position by noting the rapid expansion of geological estimates of oil reserves.

In this paper, I am attempting to reconcile Hotelling and Adelman. A parametric Hotelling analysis has considerable congruence with the Adelman perspective, and sensitivity analysis shows a 50-year period of increasing world oil use under several sets of likely assumptions.

FIGURE 1. PRODUCTION PATHS, SOCIALLY OPTIMAL AND MONOPOLY SOLUTIONS



II. A Hotelling Model with Growing Population and Income

Usually, a Hotelling approach assumes conditions which give a monotonically declining production trajectory in the absence of special circumstances such as a backstop substitute technology. However, the assumptions of the usual analysis can be defined so that there is a long period of increasing use until production and consumption fall to depletion. The innovation introduced is to assume an outward shifting demand curve in response to increasing world population and income, as in Figure 2. The short-term supply cost S_j increases slowly because of the internalization of pollution prevention costs and, perhaps, rising extraction cost. The market equilibria are Δ in Figures 2 and 3. The Δ trajectory shows the illustrative trajectory of market equilibria in the absence of a finite constraint. (This Δ trajectory can be computed numerically for both monopolistic and competitive markets as will be seen below.)

Theoretically, a competitive world oil market would act identically to a social welfare maximizing market in Equation (1):

$$(1) \quad \underset{[q(t),T]}{\text{maximize}} \; SW = \int_0^T \left(\int_0^{q(t)} (P(q,N,Y) - C(t))\,dq \right) e^{-rt}\,dt.$$

where $P(q,N,Y) = \beta_2 (e^{\theta_1 t})^{\nu} (e^{\theta_2 t})^{\epsilon} - \beta_1 q,$

$N(t) = N_0 e^{\theta_1 t}, \quad Y(t) = Y_0 e^{\theta_2 t},$

$C(t) = C_0 e^{\phi t},$

$\int_0^T q(t)\,dt \le S,$

$P, q, P - q \ge 0.$

FIGURE 2. A SEQUENCE OF MARKET EQUILIBRIA WITHOUT EFFECTIVE RESOURCE CONSTRAINT.

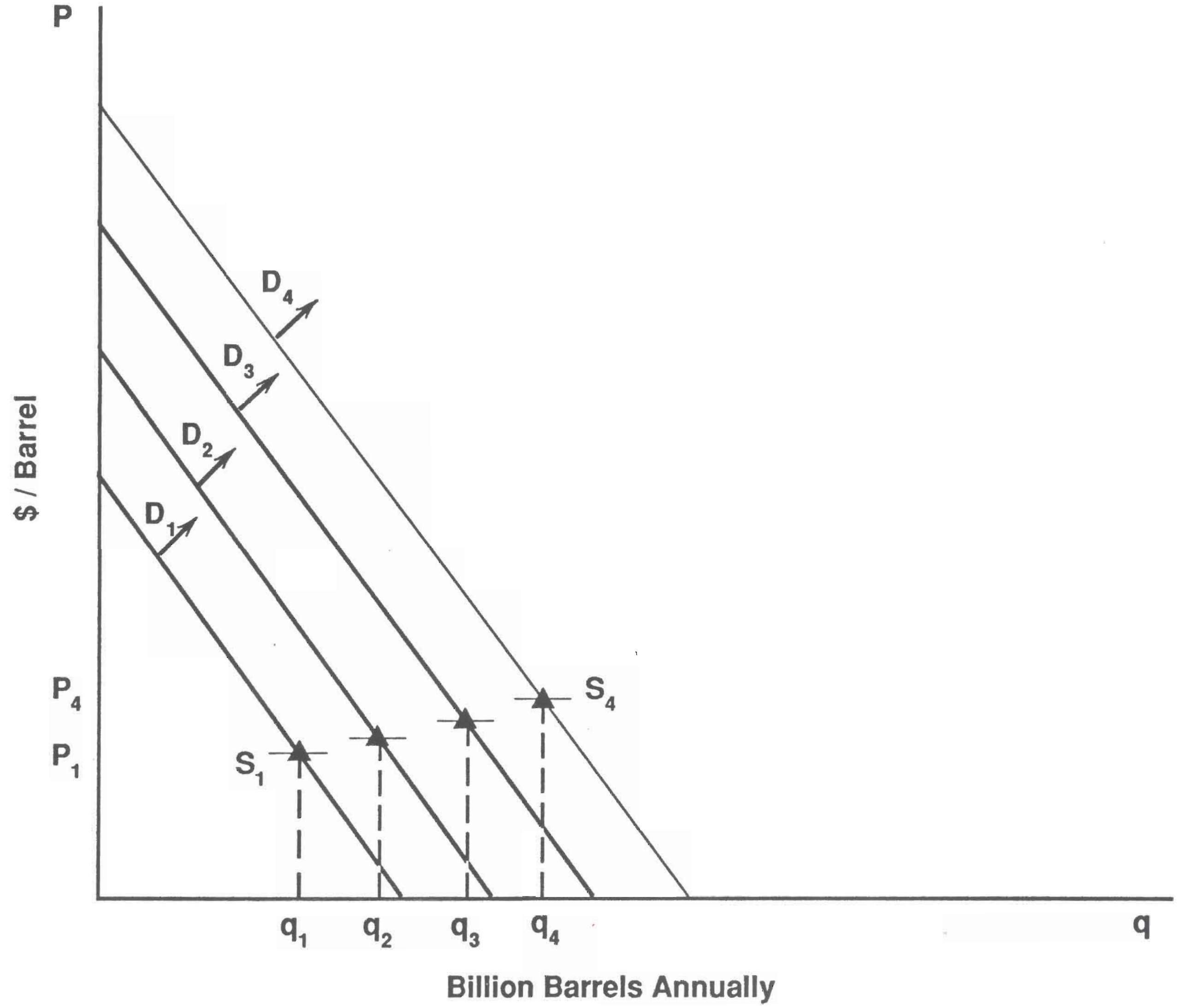
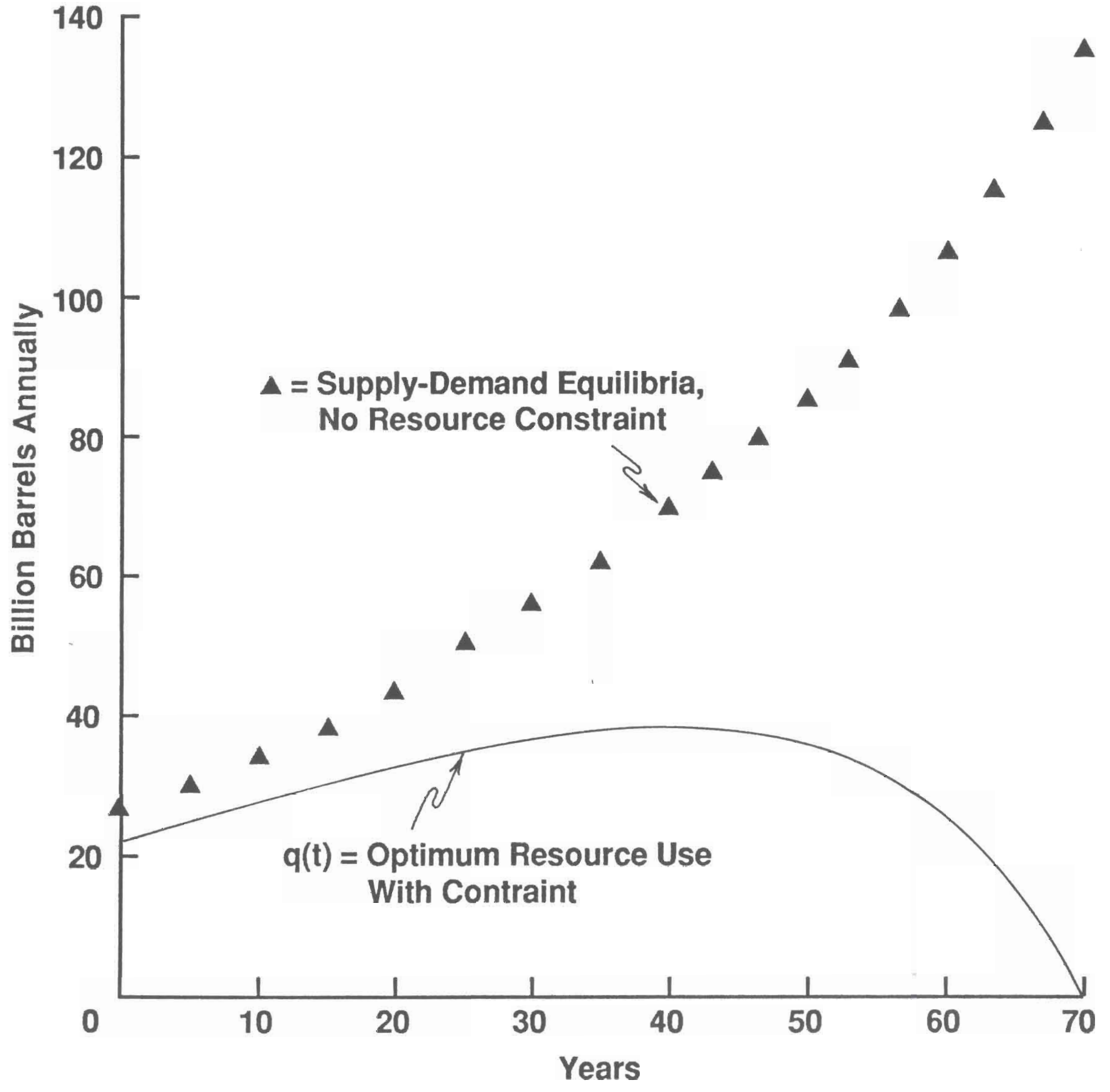


FIGURE 3. EQUILIBRIA IN THE PRESENCE AND ABSENCE OF CONSTRAINTS; COMPETITIVE MARKET.



In this problem, SW (social welfare) represents the present value of consumers' and producers' surplus. It is maximized by finding the optimal duration T of production and consumption, and the optimizing path q(t) of oil use over time. P is the price of oil, C is the actual production cost (both in $ per barrel), r is the discount rate, and S is the assumed remaining world oil resource in billions of barrels. N(t) and Y(t) are world population and per capita income, growing at rates θ_1 and θ_2, with the demand quantity elasticities of υ and ϵ.

The equivalence of social welfare maximization with competitive profit maximization is evident by comparing NPV (net present value) of consumers' and producers' surplus in Equation 2 with Equation 1:

$$(2) \quad \mathrm{NPV} = \int_0^T (P(q,N,Y) - C(t))e^{-rt}dt, \ \partial P/\partial q \equiv 0.$$

One approach to the solution of the problem is with the maximum principle in optimal control. The competitive and social welfare Hamiltonians are:

$$(3) \quad H_C = \frac{P(q,N,Y) - C(t)}{e^{rt}} - \lambda q(t), \quad \partial P/\partial q \equiv 0;$$

$$(4) \quad H_s = \frac{\int_0^{q(t)} [P(q,N,Y) - C(t)]dq}{e^{rt}} - \lambda q(t).$$

The first-order conditions for maximizing Equations (1) and (2) are identical, so a competitive oil market operating with a finite supply S is maximizing social welfare. Here, λ is interpreted as being analogous to a Lagrangian multiplier. (Formally, λ is a co-state variable.) As such, λ gives a quantitative value to dSW/dS, the increment in the discounted net present value of social welfare associated with a small increase in S, the remaining oil resource.

The solution to Equations (1) and (2) by use of the maximum principle is (Chapman, 1987, 1991):

$$(5) \quad (a) \quad q(t) = \beta_3(t) + \frac{e^{rt}}{M(r)}[S - \beta_4],$$

$$(b) \quad \beta_3(t) = \frac{\beta_2 e^{\theta t} - C_0 e^{\phi t}}{\beta_1},$$

$$(c) \quad \beta_4 = \frac{M(\theta)\beta_2 - M(\phi)C_0}{\beta_1}; \quad \text{also, } \beta_4 = \int_0^T \beta_3(t)\,dt,$$

$$(d) \quad M(\theta) = \frac{e^{\theta T} - 1}{\theta},$$

$$(e) \quad \theta = \theta_1 \nu + \theta_2 \epsilon.$$

The solution q(t) in Equation (5) has two components.[1] It equals $\beta_3(t)$, reduced by the second term. $\beta_3(t)$ is the sequence of unconstrained equilibria, with the same meaning as Δ in Figures 1 and 2. In the second term in q(t), β_4 is the total resource that would have been produced by time T in the absence of a resource constraint. So, the magnitude S - β_4 is in a sense the "scarcity" of oil resources. Equation (5) says that optimal oil production q(t) will be closest to unconstrained equilibria $\beta_3(t)$ in early years. As time passes, q(t) and $\beta_3(t)$ grow further apart. This is shown in Figure 3.

Finally, to find the precise length of time T to maximize either social welfare SW or competitive profit NPV in Equations (1) and (2), there are two possible solutions. First, if cost rises to the value of the intercept of the rising demand curve before cumulative production reaches S, then this defines optimal T^*. Second, in the other case, optimal T^* defines q(T) from Equation (5a) as zero.[2] In either case, for T^*, λ (i.e. dSW/dS) has an analytical and numerical solution.

---

[1] The solution Equation (5) has the necessary first and second order conditions $\partial\lambda/\partial t = -\partial H/\partial X = 0$, and either $\partial H/\partial q = 0$ or $\partial q/\partial t = 0$. Also, $\partial^2 H/\partial q^2 \leq 0$.

[2] These two solutions to the problem of defining optimal T^* arise from the roots of the solution to the condition that $dSW/dT^* = 0$.

These results for unique analytical and numerical values are:

$$(6) \quad T^* = \text{minimum of } T_1 \text{ or } T_2,$$

$$T_1 = T : \beta_2 e^{\theta T} = C_0 e^{\phi T},$$

$$T_2 = T : q(T) = 0.$$

$$(7) \quad \lambda = \frac{\beta_1}{M(r)} [\beta_4 - S].$$

III. Geological Data

With this done, it is possible to use generally published data as the source for assumptions, and then to use these results parametrically to examine how future trajectories of oil use may look.

The greatest controversy surrounds the existence of S, remaining resources. Adelman believes, with considerable justification, that S is not a useful concept. He writes (1992, p. 50): "We will never get to the end of our oil resources. We will stop impounding them into reserves when it no longer pays."

Watkins (1992) makes a similar point, and adds: "The theoretical outcomes to which [the Hotelling Principle] gives rise do not cope well with petroleum industry realities . . . It is disturbing that so much supply modeling goes on with only a fleeting genuflection to how the industry, in fact, operates."

Cleveland and Kaufman believe that S is determined by the Hubbert geological production cycle. They make this argument: ". . . factors that govern petroleum formation and distribution ultimately constrain discovery and production. Analysis of those factors allows analysts to estimate [S] from the historical record with a reasonable level of confidence." After considering the results which follow, it is possible that the area of disagreement can be reduced.

A geologist typically uses five concepts in defining remaining resources, as shown in Table 1. The undiscovered resources figure is the most troublesome. It is probabilistic, in the sense that geologists have used expert opinion to define a frequency distribution of possible values. Figure 4 portrays the estimates of original endowment as published in 1983 and 1991. The graph shows that, in 1983, it was believed that there was a 95% probability that the original world oil endowment was at least 1500 billion barrels, but only a 5% probability that the original resource exceeded 2600 billion barrels. Notice that over the decade there is a shift towards higher estimates with a greater shift in the lower sector. At the mean 50% probability, the growth in estimates has exceeded growth in cumulative production.

I am inclined to the position that the upper level estimates are more useful. This is because I think that the definition of economically recoverable crude oil will take in more resources as prices rise in the future. Masters et al. (1991b) indicate that their definition of conventional crude oil is keyed to a historic range upwards to $50 per barrel in 1989 dollars.

Table 1. Conceptual Definitions of Oil Resources

1. *Identified Reserves*: Economically recoverable crude oil at known reservoirs and fields with expected technology. Similar to an inventory concept.

2. *Undiscovered Resources*: Geological extrapolation of potential crude oil based upon application of knowledge of occurrence of geological formations and relationships of crude oil to geological formations. A probabilistic concept.

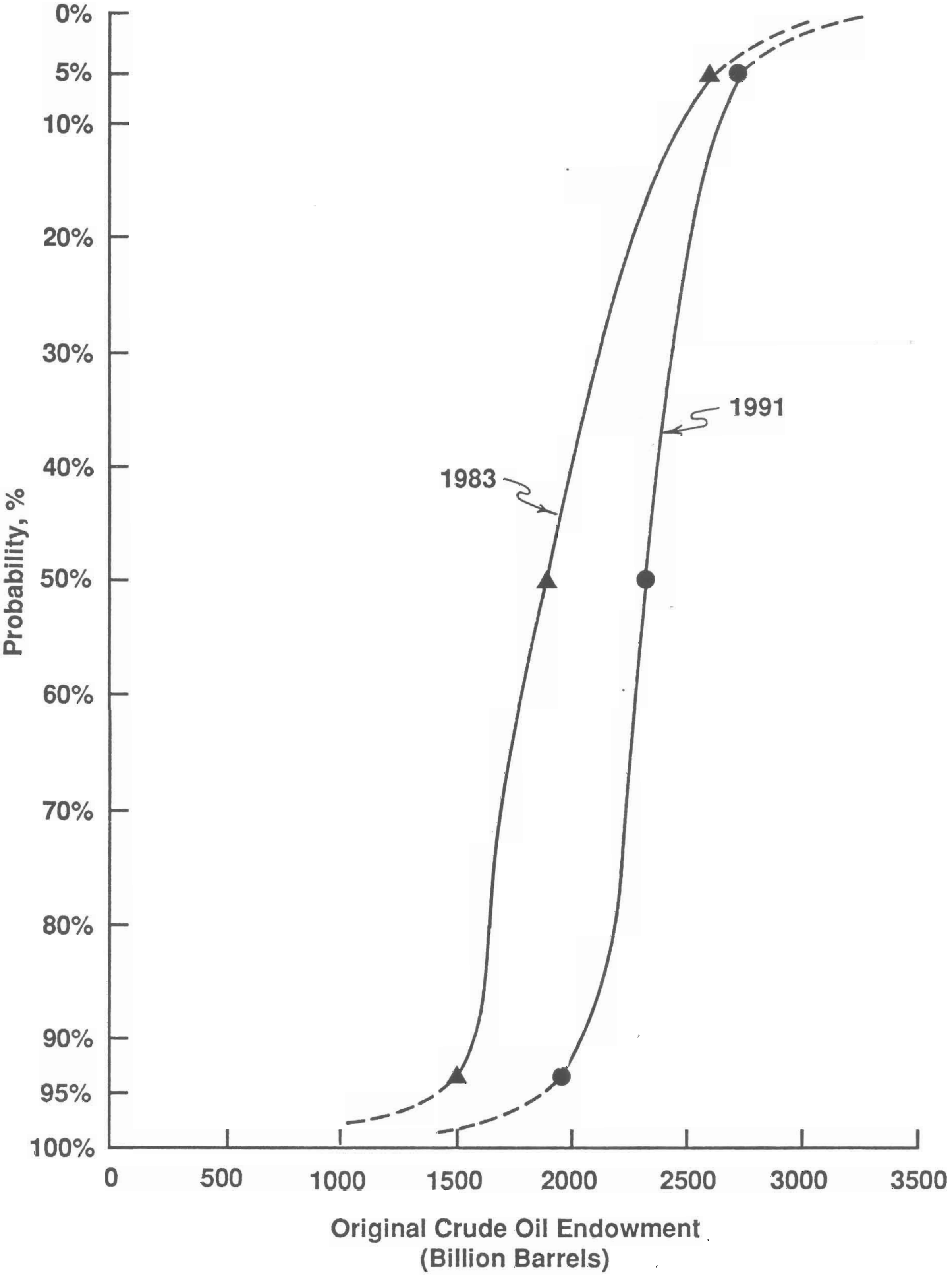
3. *Remaining Resources*: An estimate of total conventional crude oil available for recovery, the sum of the probabilistic undiscovered resources and the inventory concept of identified reserves.

4. *Cumulative Production*: The amount of conventional crude oil produced to date. Analogous to an accounting concept.

5. *Original Resources*: The estimated amount of undiscovered resources, identified reserves, and cumulative production. Consequently, it combines the probabilistic and accounting definitions.

Sources: Masters et al. (1983, 1991a, 1991b, 1987), Chapman (1983).

FIGURE 4. CHANGE IN PROBABILITY DISTRIBUTION OF ORIGINAL RESOURCES ESTIMATES



If prices rise above this, there will be more enhanced recovery, and an expansion of the definition of regions of recoverable oil. Consequently, I prefer their 5% probability figures as an economic guideline.

The purpose of adopting the 5% probability geologists' estimate is to reflect economics: the expansible concept of economically recoverable crude oil. With this definition, Table 2 shows basic global and regional quantities. We can conclude that both Adelman and Masters et al. foresee a considerable remaining resource.[3]

IV. A Depletion Model with Accelerating Use

Following Pindyck's parametric approach (1978a,b), Equations (5) and (6) can be applied to empirical data to indicate the possible pathways of future use, prices, and depletion. (The values are shown in the Appendix).

The Hotellian picture that develops has important elements that support the Adelman perspective. In Figure 5, the competitive supply-demand equilibria resulting from growing world population and income shows increasing world oil use for 41 years (i.e. to 2031). Depletion then overwhelms the population/income impact, leading to the last use in 69.44 years (i.e., 2:40 pm on June 9, 2059).

---

[3] With world use now at 22 billion barrels annually, Masters expects use to grow into the first 20 to 30 years of the next century. After this, his group expects a complex triple interaction of gradual exhaustion, political instability arising from the growing proportion of remaining oil resources in the Persian Gulf, and increasing development of substitute fuel sources.

Table 2

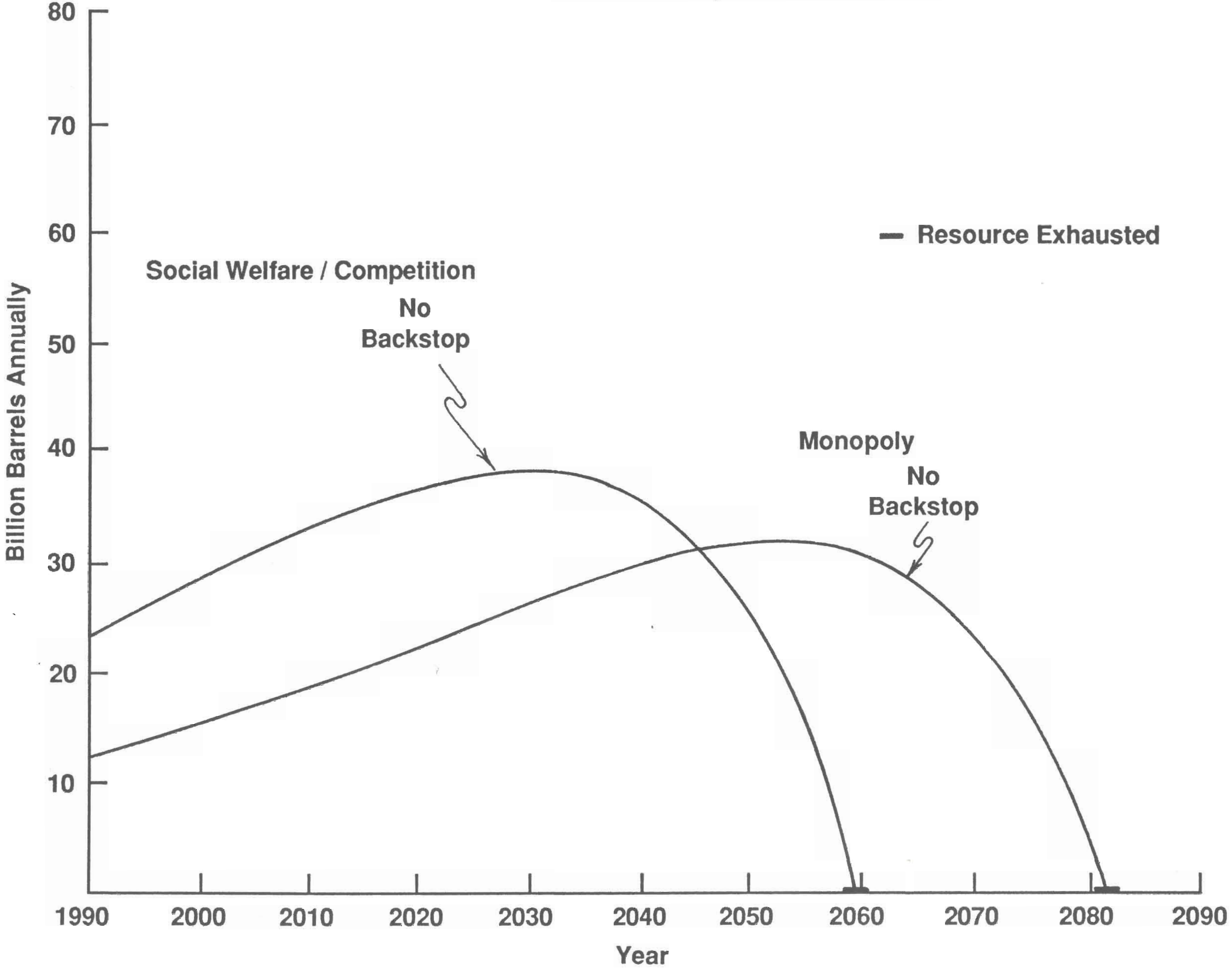
Regional and World Crude Oil, Geologists' Estimates

Billion Barrels

	Identified Reserves	Estimated Undiscovered Resources	Cumulative Production	Total Original Resources Estimate
U.S.	45	70	156	271
North Sea	36	44	17	97
Former U.S.S.R.	83	227	105	415
Persian Gulf	624	238	166	1,028
Total World	1,053	1,047	629	2,729

Note: Total includes other regions: Canada, Mexico, etc. Estimated undiscovered resources from the 5% level; see text. Cumulative production is as of 1-1-90. Remaining resources are estimated by summing the first two columns.

FIGURE 5. WORLD OIL USE, NO BACKSTOP



Of course these details are not to be taken seriously. The significance is that resource depletion theory can accommodate a period of several decades of increasing use.

The Hubbert perspective is also seen in the Figure, in that the almost-bell curve is represented. In his 1969 analysis, Hubbert's expected peak was projected to occur between 1991 and 2000. But these specific values are mere 'illustration' of a possible underlying structure.

In considering possible future monopoly in Figure 4, it can be noted that the equilibria trajectory does start at a lower value, peaks later, and lasts to a longer optimal T. The modified Hotellian application, then gives some support for Solow's famous observation (1974) that "the monopolist is the conservationist's friend."

V. A Renewable Backstop

A backstop technology introduces important consequences. As with the theoretical analysis of Dasgupta and Heal and others, the empirical Hotelling analysis gives a result of accelerating use to depletion for both market regimes.

Grain ethanol is used here. Other substitute techonolgies are also known to be workable: electric vehicles, natural gas vehicles, synthetic gasoline from coal. I have selected grain ethanol because, as a gasahol blend, it has been used for many years in the U.S., and in Brazil as ethanol from sugar cane. It is a biologically renewable source of transportation fuel.

It is assumed that $2 per gallon (in 1992 dollars) is the benchmark price of substitutability. Current ethanol production cost is in a range of around $1.50 per gallon (USDA, API, Chapman 1983). However, this cost depends upon the availability of lower cost conventional fossil fuels for on-farm and distillation use. I assume that as conventional gasoline rises to $2 per gallon (before excise taxes), the cost of ethanol would rise less slowly, becoming less costly above $2 per gallon.

The backstop technology problem basically uses Equations (1)-(7), and has the results shown in Figure 6. Note that, with both markets, world use accelerates, not simply for several decades, but to exhaustion. The price trajectories are shown in Figure 7; note the high values for the non-backstop cases. The growth in cost (C(t)) should be seen as reflecting both environmental and global warming taxes as well as a modest upward trend in actual average production cost.

VII. Conclusion

Conventional Hotelling theory of a finite resource can be modified to incorporate assumptions reflecting a shifting demand function in response to growing world population and income. With this small innovation, the depletion curve now shows a long period of growing use of world oil before use declines.

Alternatively, a renewable backstop substitute such as biomass ethanol can be hypothesized. In this case, world oil use may accelerate to depletion, reflecting both the above shifting demand and the availability of a higher cost substitute.

A parametric analysis of competitive and monopolistic markets under both types of assumptions shows a 50-year period of growing world use of conventional oil. In addition, completed shadow prices of the value of additional oil are low.

On an overall basis, the Adelman position of expected growth in conventional oil use without near-term decline is congruent with the modified Hotelling theory.[4]

---

[4] Sensitivity analysis for this paper (but not included here), and Rowse's work (1988,1990) show that these general results are unaffected by variations in parameter values.

One interesting case noted in the appendix has an effective monopoly replace a competitive market when oil use in a competitive market begins to decline. Other cases examine different probability resource levels (e.g., Figure 4 and Table 2), and parameters derived from different elasticity assumptions.

FIGURE 6. WORLD OIL USE WITH RENEWABLE BACKSTOP

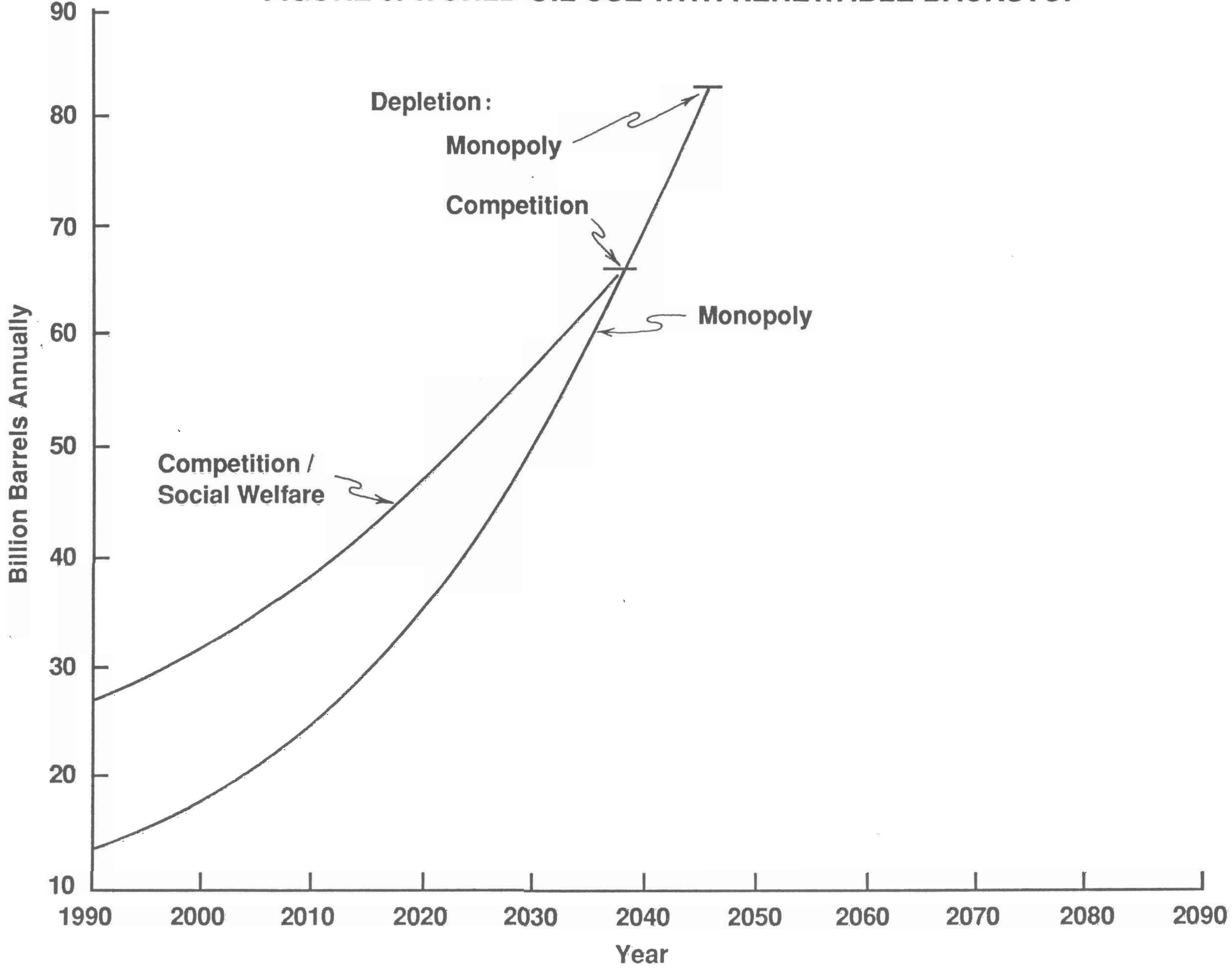
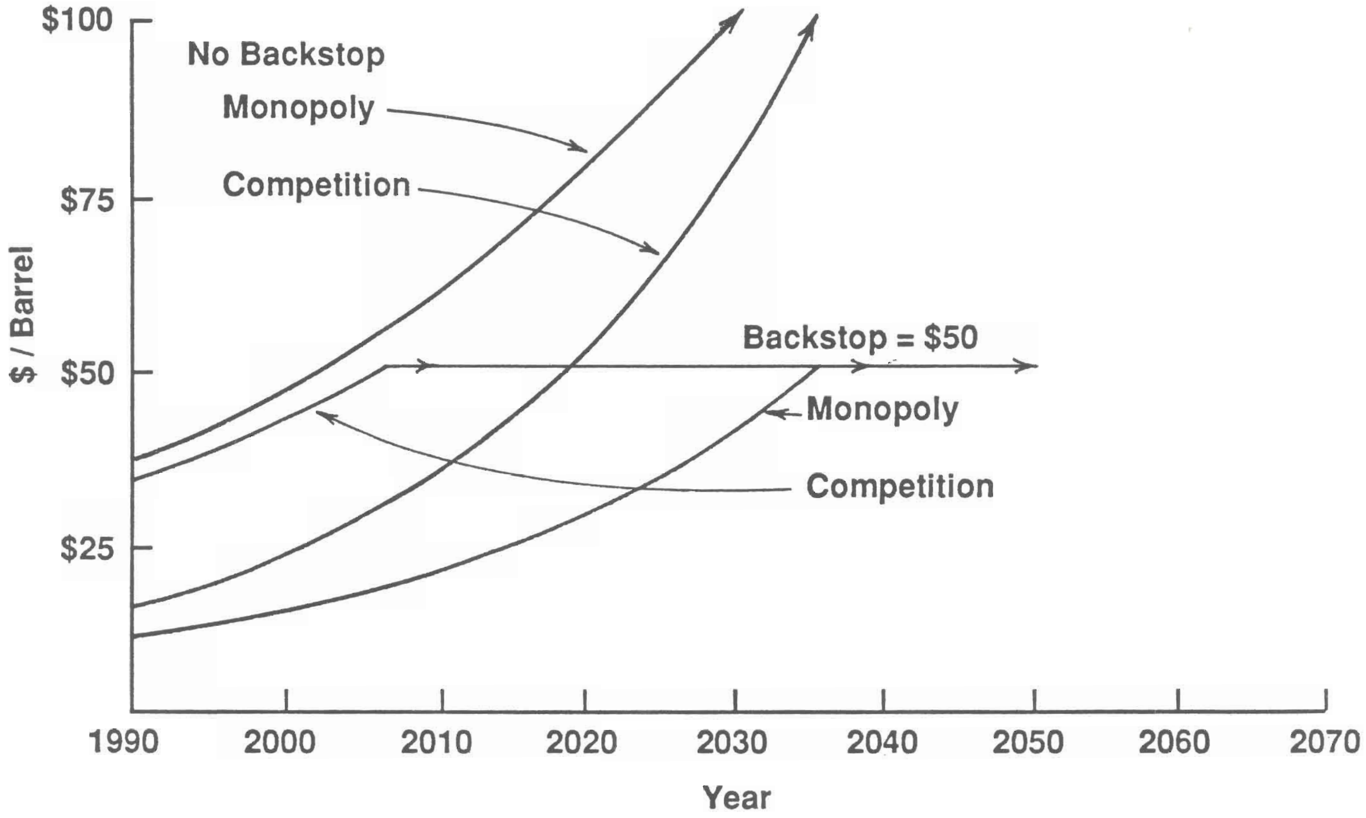


FIGURE 7. PRICES



APPENDIX

The parametric economic values are chosen to reflect middle-of-the-road elasticity estimates. The parametric cost data are based upon suggestions from unpublished and confidential sources in international oil companies. The average cost of production is assumed to be \$10/bl now, rising through \$50/bl in 100 years; $\phi = .0161$. The population and income growth rates are from the World Bank.

The long-run elasticity assumptions for energy price, world income, and world population are, respectively, -0.5, +0.5, and +1.0. These values are based upon reviews by Chapman (1987) and Drennen (1992) of empirical studies. As noted in the text, the conclusions are insensitive to plausible changes in parameter values.

Variable names and initial values as relevant are shown in Appendix Table 1. The following table (Appendix Table 2) shows T, λ, NPV, and SW for 5 cases.

APPENDIX TABLE 1. DEFINITIONS OF VARIABLES

Variables	Definitions (initial value if applicable)
β_1	Quantity coefficient in price demand function (1.8)
β_2	Parameter in price demand function intercept shift (60)
$\beta_3(t)$	Time path of unconstrained supply-demand equilibria
β_4	Total resource that would have been used in the absence of a resource constraint
ϵ	Elasticity of demand with world per capita income (0.5)
θ_1, θ_2	Growth rates in world population and per capita income (1.37%, 1.60%)
θ	Aggregate growth rate of world population and income weighted by demand elasticities (1.61%)
λ	Dynamic Lagrangian multiplier, the increase in welfare from another barrel of crude oil added to the remaining resource
υ	Elasticity of demand with world population (1.0)
ϕ	Growth rate in oil production cost
$C(t)$	Average cost of production, crude oil (C_0=\$10/bl)
H_c, H_s	Hamiltonian functions for competitive world market and for social welfare maximization
$M(x)$	Accumulation function for variable x
$N(t)$	World population (N_0=5.3 billion)
NPV	Net present value of producers' surplus
$P(t)$	Price of crude oil
$q(t)$	Time path of optimal oil use
r	Real interest rate (.05)

S	Stock of remaining crude oil, the sum of the identified reserves and, here, the 5% probability estimate of undiscovered resources (2,100 billion barrels)
T*	Optimal duration of use of remaining oil
SW	Social welfare, the present value of consumers' and producers' surplus
Y(t)	World per capita income (Y_0 = $4000)

APPENDIX TABLE 2. CASE COMPARISON OF PRESENT VALUE RESULTS

	T years	λ \$/bl	NPV in billion \$	SW in billion \$
1. Competition	69.44	\$7.46	\$15,659	\$31,561
2. Monopoly	91.78	\$4.02	\$21,469	\$27,980
3. Shift from competition to monopoly, year 41	80.80	na	\$16,153	\$31,224
4. Competition with backstop	47.67	\$2.63	\$5,519	\$29,365
5. Monopoly with backstop	55.20	na	\$14,876	\$17,522

Note: NPV is net present value of producers' surplus or rent. SW is social welfare, the present value of consumers' and producers' surplus.

BIBLIOGRAPHY

Adelman, M.A., "Finding and Developing Costs in the United States, 1945-1986," in John R. Moroney, ed., *Advances in The Economics of Energy and Resources: Energy, Growth and the Environment*, Greenwich, CT.: JAI Press Inc., 1992, 7, 11-58.

Adelman, M.A., "Mineral Depletion, With Special Reference to Petroleum," *The Review of Economics and Statistics*, February 1990a, 72(1), 1-10.

Adelman, M.A., "The 1990 Oil Shock is Like the Others," *The Energy Journal*, October 1990b, 11(4), 1-13.

Adelman, M.A., "Mideast Governments and the Oil Price Prospect," *The Energy Journal*, April 1989, 10(2), 15-24.

API: American Petroleum Institute, *The Economics of Gasoline Ethanol Blends*, Washington, D.C., 1988.

Cleveland, Cutler J. and Kaufmann, Robert K., "Forecasting Ultimate Oil Recovery and Its Rate of Production: Incorporating Economic Forces into the Models of M. King Hubbert," *The Energy Journal*, April 1991, 12(2), 17-36.

Chapman, Duane and Barker, Randy, "Environmental Protection, Resource Depletion, and the Sustainability of Developing Country Agriculture," *Economic Development and Cultural Change*, July 1991, 39(4), 723-37.

Chapman, D., "Computation Techniques for Intertemporal Allocation of Natural Resources," *American Journal of Agricultural Economics*, February 1987, 69(1), 134-142.

Chapman, D., *Energy Resources and Energy Corporations*, Ithaca, NY: Cornell University Press, 1983.

Conrad, Jon M. and Clark, Colin W., *Natural Resource Economics*, New York: Cambridge University Press, 1987.

Drennen, Thomas, *Climate Change Policies and Developing Countries*, Ph. D. Dissertation, Cornell University, Ithaca, NY, 1992.

Hotelling, Harold, "The Economics of Economics of Exhaustible Resources," *The Journal of Political Economy*, April 1931, 39(2), 137-75.

Hubbert, M. King, "Energy Resources," in Committee on Resources and Man, National Academy of Sciences-National Research Council, *Resources and Man*, San Francisco: W.H. Freeman and Co., 1969, pp. 157-242.

Masters, Charles D. et al., *World Resources of Crude Oil and Natural Gas*, Review and Forecast Paper, 13th World Petroleum Congress, Buenos Aires, 1991.

Masters, C.D., Root, David H. and Attanasi, Emil D., "Resource Constraints in Petroleum Production Potential," *Science*, July 1991, 253, 146-52.

Masters, C.D., Attanasi, E.D. and Dietzman, William D., et al., "World Resources of Crude Oil, Natural Gas, Natural Bitumen, and Shale Oil," in 12th World Congress, *Proceedings*, 1987, 15, 3-27.

Masters, C.D., Root, D.H. and Dietzman, W.D., *Distribution and Quantitative Assessment of World Crude-oil Reserves and Resources*, United States Department of the Interior Geological Survey, Open-File Report 83-728, 1983.

Pindyck, Robert S., "The Optimal Exploration and Production of Nonrenewable Resources," *Journal of Political Economy*, October 1978a, 86(5), 841-61.

Pindyck, Robert S., "Gains To Producers From the Cartelization of Exhaustible Resources," *The Review of Economics and Statistics*, May 1978b, 60(2), 238-51.

Rowse, John, "Using the Wrong Discount Rate to Allocate an Exhaustible Resource," *American Journal of Agricultural Economics*, February 1990, 72(1), 121-130.

Rowse, John, "Does an Exhaustible Resource Usually Have Many Near-Optimal Depletion Paths?" *American Journal of Agricultural Economics*, August 1988, 70(3), 646-53.

Stiglitz, J.E., "Monopoly and the Rate of Extinction of Exhaustible Resources," *American Economic Review*, September 1976, 66, 655-61.

USDA: U.S. Dept. of Agriculture, Economic Research Service, *Ethanol: Economic Policy Tradeoffs*, 1988.

Watkins, G.C., "The Hotelling Principle: Autobahn or Cul de Sac?" in Presidential Address, International Association for Energy Economics, *The Energy Journal*, January 1992, 13(1), 1-24.

World Bank, *World Development Report 1991, The Challenge of Development*, Washington, D.C.: Oxford University Press, 1991.

OTHER AGRICULTURAL ECONOMICS WORKING PAPERS

No. 91-21	A Complete, Three-Level Demand System for Foods in Japan	John Dyck Timothy D. Mount
No. 92-01	A Theory of Competition Between Politicians for Political Support	Jo Swinnen Harry de Gorter
No. 92-02	Negotiating a Response to Climate Change: The Role of Biological Emissions	Thomas E. Drennen Duane Chapman
No. 92-03	Environment, Income, and Development in Southern Africa	Duane Chapman
No. 92-04	Data Requirements for Energy Forecasting	Timothy D. Mount
No. 92-05	Oil Shocks and the Demand for Electricity	Edward C. Kokkelenberg Timothy D. Mount
No. 92-06	The Effects of Carbon Taxes on Economic Growth and Structure Will Developing Countries Join a Global Agreement?	Steven C. Kyle
No. 92-07	Climate Change, Sustainable Economic Systems and Welfare	Timothy D. Mount
No. 92-08	Welfare Effects of Improving End-Use Efficiency: Theory and Application to Residential Electricity	Jesus C. Dumagan Timothy D. Mount
No. 92-09	The Value of Segmenting the Milk Market into bST-Produced and Non-bST-Produced Milk	Loren W. Tauer