WORKING PAPER
ALFRED P. SLOAN SCHOOL OF MANAGEMENT

Economic Theory and Ocean Transportation of Oil

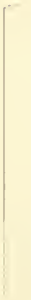
By

Zenon S. Zannetos

October 1976

WP 880-76

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139



Economic Theory and Ocean Transportation of Oil

By

Zenon S. Zannetos

October 1976 WP 880-76

Economic Theory and Ocean Transportation of Oil

By

Zenon S. Zannetos

The subject of this presentation is economic theory and oil transportation by ocean going vessels. I must at the outset admit that it is very pretentious for anyone to even attempt a topic such as this, let alone to be all encompassing, given the breadth and depth of economic theory. So I will limit myself to certain aspects of economic behavior as these aspects affect the supply and demand of ocean transportation capacity and eventually determine tanker rates. As for the latter, I will attempt to cover both spot and period rates, within, of course, the scope of the economic issues with which I will be dealing.

One of the things that strikes the student of tanker markets is the great fluctuation as well as volatility of tanker rates. Over time, these fluctuations have caused "feast and famine" situations with repetitive, if not regular cycles. Very few markets behave so violently as to allow rates which, if they were to hold, would enable those who operate therein to recover their total fixed investment in a short period of a year (actually four to five trips from the Persian Gulf to U.S./Continent). But as everyone knows, these rates do not stay long at those meteoric levels. Suddenly the rates plummet with even greater speed than they rise taking with them many operators down to a mere sustenance level, if not virtual bankruptcy. During the recent upheaval of October 1973, rates

reached Worldscale 450 (one transaction reportedly was consummated at Worldscale 650) but in one month the rates were down to Worldscale 55, or to less than 1/8 of the highest point reached. The decline continued and rates for VLCCs reached an average level of Worldscale 17 1/2 in the spring of 1975, far below the out-of-pocket rate even for these vessels.[1]

There are several aspects of economic theory which help us understand at least partially the behavior of tanker markets. Following the traditional approach of economists we will single out some major theoretical forces impacting the demand and supply of transportation capacity.

1. The Theory of Demand

Transportation adds spatial utility to crude oil and to oil products. Although we are dealing here with what is mainly an input to production and which properly belongs to what we might call "producer demand," in order to understand the behavior of tanker markets we must also study "consumer demand." The reason for this, is that most transportation departments of oil companies are still operated as cost centers, and as such they operate under budget constraints similar to those of households. In addition, transportation is one of those unique industrial inputs which are not transformed into the output. In markets such as oil, where C.I.F. pricing is predominant for sound economic reasons,[2] the similarities between the demand for transportation capacity and consumer demand are further accentuated. One must, therefore, attempt

[1] At such rates a VLCC does not even cover the round trip full cost of the fuel and of the port charges.

[2] For an analysis of these reasons see: Zannetos, Zenon S., "Some Problems and Prospects for Marine Transportation of Oil in the 1970s," SSM Working Paper 649-73. Chapter in Energy: Demand, Conservation, and the Institutional Problems, Ed. by Michael S. Macrakis, M.I.T. Press, 1974, pp. 403-416.

to derive all the consequences of this similarity.

As you may recall, one of the differences between the producer as contrasted to the consumer demand, lies in the income effect of a price change. A price change facing a consumer can be decomposed into an income effect (reflecting a real income increase if there is a price decrease and a decrease if there is a price increase) and a substitution effect, resulting from the tendency of consumers to substitute commodities whose prices increase with other commodities. In the normal case of a producer demand, we have a substitution effect, but no income effect.

The substitution effect in the case of a firm (producer) is less likely to be as strong as in the case of a consumer when faced with a proportionate price change of an item he purchases. The reason is that the products of a firm, as well as the inputs used, tend to be technically complementary rather than substitutable.[3] In the case of tanker transportation, most of the relevant units of the oil companies tend to behave like consumers, with a strong income effect of a price change but weak static substitution effect, because of the difficulty of finding viable alternatives to tankers for transporting oil over the oceans. This inability to find substitutes to tankers is especially evident in the short run. As for the long run the extreme complementarity between tankers and oil is expected to persist. If oil is replaced by other sources of energy which do not need to be transported by tankers then we would expect long run substitution effects.

---

[3] For an extensive discussion of demand see J. R. Hicks, Value and Capital, Oxford, England, 1953, Chapters II and VII.

The above discussion of the static substitution effect must be distinguished, however, from the dynamic impact of the price-elastic expectations which causes strong interperiod substitutions, and which we will discuss shortly.

The independent owners of tankers do not necessarily behave the same way as the cost of oil companies. However, to the extent that the behavior of oil companies is dominant and given that we are dealing with a specialized market governed by derived demand, then the independents are expected to manifest for the most part a behavior which is consistent with that of the oil companies.

2. Elasticity of Expectations

Another area of economic theory which is vital for our understanding the tanker markets is that of expectations. Implicit behind the downward sloping demand curve is the notion of the inelasticity of price expectations. In other words, we assume that a price increase let us say, normally raises expectations that all future prices of the commodity in question will increase proportionately less than what was previously expected. The same goes for a price decrease. This encourages people to postpone purchases when prices go up and advance purchases when prices go down. In the case of producer goods, price increases, under the assumption of inelastic price expectations, encourage postponement of purchases of inputs and acceleration of output. The opposite is expected to hold for price decreases.

In the tanker markets we notice that the majority of those involved exhibit price-elastic expectations. All these expectations are derived (that is to say, are not direct) but those of the independents are even more indirect because the demand facing them is derived from Transportation

Departments of oil companies whose demand in turn derives from the needs of Supply and Distribution Departments. Obviously, there are some operatives in the tanker markets who behave in a manner consistent with the classical theory of demand. The total result, however, reveals that price-elastic expectations are dominant.[4]

A knowledge of the assumptions which underly the economic theory of consumer and producer demand enables us to derive the consequences of violation of these assumptions. We find, for example, by analyzing the implications of price-elastic expectations and of the application of consumer behavior to tanker markets, that:

(a) the normal long run equilibrium spot rate is unstable;[5]

(b) the rates will not continue to increase or decrease in an explosive fashion[6] but are bounded; and

(c) the only plausible theoretically stable equilibria are at either very "high" rates or very "low" rates. The high rates reflect the revenue (delivered price of oil) to be derived through transportation activities, in the short run, and the low rates reflect the refusal price of the then marginal vessels which operate in the spot market, again a short-run notion. That is the reason why we have feast and

[4]For an extensive discussion of these issues see: Zannetos, Zenon S., The Theory of Oil Tankship Rates, M.I.T. Press, 1966, pp. 6-29, 42-49, 77-80, and 102-105.

[5]To be exact, the long-run equilibrium rate may be stable but any disequilibrating adjustments will send the rates to either very high or very low rates. It all depends upon the range, if any, of the demand schedule over which inelastic expectations and strictly static forces hold, and on the accidental balance between supply and demand at exactly such a normal long-run rate, as to whether such an equilibrium may be observed.

[6]The traditional assumptions of economic theory dictate this. See Hicks, op. cit., p. 251 and J. W. Baumol, Economic Dynamics, The Macmillan Company, New York, 1957, p. 255.

famine situations in the tanker markets. We must note, however, that the forces behind the supply schedule make even these equilibria (at very high and very low rates) short lived.

3. Supply Theory

Let us now look at the economic theory underlying the short-run and long-run supply schedules in order to understand the reasons why high rates do not last as long as low rates, and why fluctuations around any observed equilibria are quite common. To do that we must fit several parts of the economic system together.

First of all, we must extend the price-elastic expectations theory to the area of shipbuilding. Empirical evidence tends to support the hypothesis that orders placed for new tankers are a function of spot rates and that these orders do not stop until after the "need" which necessitates them disappears. That is to say new orders stop only months after the spot rates drop precipitously. If we take the two most pronounced spot rate increases, those of 1956 and 1973, we find that in 1956 rates reached their peak, Scale 460,[7] in December 1956. As a result of this and by September 1957 the backlog of orders stood at 94% of the total fleet.[8] We must observe that spot rates took a precipitous slide in March 1957. For the 1973 crisis, the spot rate reached Worldscale 295 in June and a peak of Worldscale 450 in October 1973. On December 31, 1973, the tonnage of tankers on order was 93% of the total fleet, although the rates had fallen to Worldscale 55, by November 1973.[9] During the first half of 1974, an additional 20.8

---

[7] At the time we were dealing with Scale No. 2 which started from minus 100. So the recorded rate was Scale plus 360 or 460.

[8] Zannetos, Zenon S., The Theory of Oil Tankship Rates, op. cit., p. 114-115.

[9] See Conrad Boe Ltd., Estimated Tanker Market Rates (Chart) and John I. Jacobs, World Tanker Fleet Review, London, December 1973, pp. 6-7.

million tons of new orders were placed but this obviously did not match the record of 60 million tons of orders placed during the last six months of 1973.[10]

Of course the absolute magnitudes during the 1956 and 1973 crises were different. In September 1957 the backlog was about 41 million D.W.T. but in December 1973 it was approximately 198 million D.W.T. The point that needs to be stressed, however, is that the impact of price-elastic expectations seems to extend to the tankship building markets, creating lumpiness in investment, and, through the well-known economic accelerator effect, also impacting shipbuilding capacity. The euphoria, however, does not last long. Soon many charterers exhaust their budgets[11] and those who do not, find it difficult to secure any vessels for hire. The charterers now begin to realize that they can get by without more tonnage. In fact a lot of the tankers they forward-chartered (because of the interperiod substitution effect of price-elastic expectations) are not being utilized. So the demand for transportation capacity facing the industry shifts to the left, it virtually dries completely, the scarcity disappears, and surpluses become evident.

At the same time some of the vessels in the huge backlog are being delivered creating further surpluses, and adding to the deteriorating situation. The net result of all this is a steady stream of new vessels at a time when charterers are long in tonnage, the rates go below the out-of-pocket cost for many vessels, and the dawn of a very depressed period for tankers begins.

---

[10] John I. Jacobs, World Tanker Fleet Review, London, June 1974, p. 3.

[11] Even those who operate as "profit centers" (not cost centers with fixed budgets) "exhaust their budgets" because the tanker rates, per ton of oil delivered, are higher than the total gross revenue to be derived from the oil sold.

The above observations explain the plight of shipyards, and the magnitude of surpluses that are created by the price-elastic behavior explains the long duration of depressed market conditions.[12] It also becomes clear from our discussion why the high rates do not last very long.

The shape of the long-term supply schedule seems to be very elastic and shifting downward. This is due to the change in the composition of the fleet, as time goes by, and to the extensive economies of scale that are realized with the increased size of vessels. The average size of tankers in the fleet is only about 85,000 D.W.T., with a range reaching from the T-2 to 520,000 D.W.T. The average size of all vessels of 10,000 D.W.T. and over in the backlog is approximately 143,000 D.W.T. As the new vessels enter into the market the average size of the tankers in the fleet increases and the supply schedule shifts downward. To appreciate the relative magnitudes involved, the rate which will give the owner of a 30,000 ton vessel an 11% return on investment after taxes is Worldscale 136.6, while the comparable rate for an 85,000 ton vessel is 74.8, and for a 520,000 ton vessel Worldscale 31.2.[13]

---

[12] To determine the duration of low spot rates one must postulate a rate of growth in requirements, estimate the rate of scrappage of old vessels and calculate the the time it takes to absorb the surplus tonnage. Because new investment in ships is "lumpy," retirement is also most likely to occur in chunks by vintage.

[13] These cost calculations were performed by Stamatios Polemis as part of his Master's thesis, Tanker Time Charter Rates: An Application of a Theoretical Model, M.I.T., June 1976. The assumptions here are that the relevant shipbuilding costs were those of 1972, the operating costs those of 1975, and that the ship owner assumed a loan for eight years at 8% for 80% of the cost of the vessel. If we were to use 1974 shipbuilding costs the respective rate for a 520,000 ton vessel would increase to Worldscale 33.6.

With this much heterogenity in tanker sizes one may conclude that we are dealing here with very imperfect markets. This is not necessarily so. As I pointed out elsewhere,[14] the existence of a structure of spot rates (different rates for vessels of different sizes) is not the result of market imperfections but on the contrary, it is for the most part the result of an efficient market, which distributes the economies of size to the parties who assume the risk of underemployment and the cost of the necessary coordinative mechanisms that size dictates. Given that at any moment in time there is an objective method of determining the economic consequences of existing differences between vessels, complete homogeneity is not necessary for market efficiency.

The short-term supply schedule, again for good economic reasons, is very elastic up to the point of 93% capacity utilization and after 95% becomes almost infinitely inelastic. The planning for withdrawal and reentry into the market is always lagging one decision period behind the manifestations of the outcome. For this reason we see gyrations around the various "stable" equilibria resembling those of the classical "cobweb" theorem, causing fluctuations in rates.

4. Theory of Value Under Uncertainty

If we now briefly look at period (time charter) rates we find that, in addition to the other areas already discussed, we need to resort to those aspects of economic theory which deal with the theory of value

[14] See "Freight Rates," World Ship Charter Market Forecast 1975-1980, Alcan Shipping Services 1975, Vol. 2, Sec. B, pp. 25-43.

under certainty and uncertainty and with the theory of interest[15] such knowledge is extremely helpful in enriching our understanding of what period rates represent and of what is and ought to be their relationship to spot rates. As you may well appreciate the subject of time-charter rates is very complex. It encompasses, in addition to all those problems of level and structure, which are present in the determination of spot rates, issues associated with the time duration of the contractual commitments.

Under conditions of certainty, the period rates should be the weighted average of the spot rates over the duration of the period charter, properly discounted by the relevant interest rate.[16] As all of us know, however, there is a lot of uncertainty not only with respect to the level of interest rates but also with respect to all the factors that are particular to tanker rates.

We have already touched on the risk of underemployment at the time we discussed the structure of spot rates. In the case of period or time charter rates in addition to the impact of underemployment we have also:

(a) the risk of unemployment; for any vessel operating in the spot market there is an expected loss of idleness associated with it over any given time period. This expected loss is shifted to the charterer, if the vessel were to be operated under a time charter, and reflected in the time-charter rates;

---

[15] The theoretically inclined student of this subject is well advised to look to the relevant material in economic classics such as: Böhm von Bawerk, Eugene, Ritter, Capital and Interest: A Critical History of Economical Theory (translated by William Smart), Kelley and Millman, New York, 1957, especially Book I, Chapters IV and V and Book II; Fisher, Irvin, The Theory of Interest, A. M. Kelley, New York, 1965; Hicks, Value and Capital, op. cit.; and Knight, Frank H., Risk, Uncertainty and Profit, Harper and Row, New York, 1965.

[16] The time charter rate is usually uniform over the duration of the contract. Discounting is necessary in order to equalize the present value of the two revenue streams.

(b) the uncertainty with respect to the level and structure of interest rates;

(c) the risk of price changes in the out-of-pocket input factors born by the shipowners;

(d) the risk that vessels of a particular size class will lose, over their life time, the comparative advantages they enjoy at the time; and

(e) the risk with respect to price changes in the input factors born by the charterer and which price changes will change the comparative advantage of specific vessels within a certain size class.

The theory of interest tells us that depending on the prevailing expectations the long-term rates may be different than the short term rates.[17] If the dominant expectations are that the short-term rates in the future will be lower than those observed in the present, then the present long-term rates will be lower than the present short-term rates. The opposite holds if the expectations are in the opposite direction.

Time charter rates behave in the same way as long-term interest rates, but for those other dimensions of risk and uncertainty that I have enumerated. In the absence of any dimensions of risk, capital theory tells us that the rate for a charter of a duration equal to the life of the vessel ought to be equal to what I have elsewhere

[17] Let us ignore for this purpose the costs of consummating a loan agreement and of changing investment plans.

described as the break-even time charter rate of the vessel.[18] In other words, a rate which will guarantee over the life of a vessel a "fair" return to encourage reinvestment. So the longer the duration of a time charter the closer the rate ought to be to the break-even time charter rate because most of the dimensions of risk are shifted from the owner to the charterer. The list of these risks effectively shifted to the charterers for the duration of the charter agreement includes, underemployment, unemployment and the risk associated with the loss of the comparative advantages of the chartered vessel. The only major risks that the owner cannot fully shift to the charterer, through a lengthy time charter agreement, are those inherent in the changing level and structure of interest rates,[19] and the change in the price of the input factors for which the ship owner is responsible. Unless, of course, the time charter agreement provides for cost escalations.

With uncertainty and charters of shorter duration than the life of a vessel entering into the picture, we get a whole structure of time charter rates depending on the level of spot rates. As the duration of the time-charter agreement is extended, the period rates asymptotically approach the theoretical break-even time charter rate of the specific vessel, from above when the spot rate is higher and from below when the spot rate is lower than the break-even rate.

---

[18] Zannetos, Zenon S., "Theoretical Factors Affecting the Long-Term Charter Rate for Tankers in the Long Run and Suggestions for Measurement," M.I.T. Working Paper No. 118, 1965 and Zannetos, Zenon S., "Time Charter Rates," Analysis of of World Tank Ship Fleet, December 31, 1966, Sun Oil Company, Philadelphia, Pennsylvania, July 1967, pp. 1-42.

[19] Even these risks can be partially shifted because of the mortgagability of the time charter agreement.

> The theory of value under uncertainty and the theoretical reasons which dictate that the vessel operate like a firm,[20] explain why the financial costs must be charged to the cash flow of the project and not be included in the cost of capital of the organization. For the same theoretical reasons we can conclude that the tanker operations of oil companies, and I must add those of the oil producing countries, are likely to be at a competitive disadvantage vis a vis those of the independents, unless some drastic changes in their management and organization structure is effected.[21]

So let me close now by expressing my conviction that economic theory helps us in many ways understand the level and structure of tanker rates. Obviously, within this short paper I have not done full justice to what I have attempted, but I may have hopefully whetted the appetite of some of you who are interested in maritime transportation to look further into this topic.

---

[20] See The Theory of Tankship Rates, op. cit., pp. 182-183.

[21] Another alternative, of course, is for one to close his eyes and subsidize inefficiency, which inefficiency the oil producing countries may be able to afford but the oil companies no longer can.