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COST STRUCTURE AND PERIOD RATES FOR OIL TANKERS

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I. Introduction: A Model for Long Term Rates in the Long Run

One of the most important determinants of the long-term charter rate in the long run is the short-term rate at the point of the transaction. The reason for this is that the short-term rate incorporates in it certain fundamental structural relationships between supply and demand that are valid over time, and are reflected in the operations of the tankship markets. With the exception of a small percentage of tanker capacity that is used for marginal trades, such as grain, vegetable oils and molasses, the demand for tonnage on spot is the difference between the total demand for independent tonnage and the time-charter demand. The same can be said of the supply side of the market. This circularity is necessarily reflected in the rates. As a result, with the exception of the uncertainty premiums that we will shortly explain, at any moment of time, spot and the long-term rates are interdependent.

In using the short-term rate in a model for time-charter rates in the long run, we must therefore divorce the former from any short-run fluctuations that do not reflect basic structural relationships which are valid over time. Otherwise, the long-term rate that we will be determining will be a long-term rate in the short run. Consequently the model that we will propose will include only "normal" short-term rates.

The model to be tested from 1970 to 1980 is of the form R_L function (R_s, X_1, X_2, X_3, X_4, X_5,E), where R_L is the long-term rate, R_S is the short-term rate, X_is are certain risk premiums and E random error, all functions of time.

R_s is not equivalent to the empirical market short-run rate because the market short-run rate may reflect at any moment of time market imperfections. We are here concerned with a rate that is based on the long-run supply schedule of the industry. It includes the minimum necessary return to guarantee replenishment of the required investment and also reflects the normal condition of uncertainty of employment. To the extent that no one will be encouraged to invest unless he expects to earn the minimum necessary return on his investment, R_s may be based on the long-run cost of the marginal block of vessels at the time the transaction takes place.

The definition of what constitutes the "marginal block" of vessels is not intuitively obvious. It cannot refer to the class of the smallest vessels operating in the markets because these vessels are mostly used for special purposes such as for transporting oil to isolated harbors which are not equipped to handle larger vessels. Furthermore, vessels operating on time charters are usually used for transporting crude oil and not refined products. For the latter, smaller vessels are normally used because of constraints imposed by the size of markets. As a result, whenever at any moment of time, we wish to define the "marginal capacity" for time-charter purposes, we must think of the marginal vessels which normally operate in the crude trade for major routes and not of the smallest vessels operating in the most marginal trade of the most marginal route.

Finally there is another requirement that we must impose on our definition before we calculate the normal short-term rate. The vessel chosen as marginal must belong to a class that represents at least 5-10% of the total tonnage. If not, it will not be very influential in rate setting. Luckily this requirement can be easily met since tankers are built in sizes that belong to representative classes.

The impact of any errors in measurement because of the above assumptions concerning the determination of R_s, or any imperfections and bias in the basic statistic itself, will be corrected by variables X_1, X_2, X_3, X_4, X_5 as we will shortly explain.

A. Two Aspects of Risk: Underemployment and Unemployment

One of the reasons for the differences between the normal spot rate under uncertainty and the time-charter rate (in both the short run and the long run) is what one may call the risk premium. Vessels that operate in the spot market run the risk of underemployment as well as unemployment; consequently R_s must include a premium commensurate to these risks. Under long-term contracts these risks are shifted from the owner to the charterer.

1. The Risk of Underemployment

The risk of underemployment is caused by the inflexibilities of size. A large vessel reflects potential economies of scale which can be realized if the proper co-ordination and information flow is achieved. In order to avoid costly delays and idle capacities, a careful and sensitive scheduling process must precede the utilization of facilities. This scheduling activity is costly and will only be undertaken of course if the benefits from the reduction of uncertainty surrounding the probable values of the expected output are greater than the cost of the co-ordinative system.

Another factor effecting underemployment and also entering into the co-ordinative system relates to the nature of ancillary facilities. In order that a charterer may utilize effectively tankers of let us say, 500,000 D.W.T., he must make sure that:

(a) The potential loading and unloading ports have berth facilities for 500,000 D.W.T. tankers. If not, one must arrange for off-shore loading and unloading.

(b) The depth of the harbors, rivermouths and canals is sufficient for the "draft" of the vessel.

(c) The proper balance between receipts of crude oil and refining capacity is reserved. A tanker of 500,000 D.W.T. can provide in one trip enough crude oil for approximately ten days of operation for a refinery of 350,000 barrels per day of through-put capacity. On-shore storage facilities can provide some flexibility, and allow the use of larger tankers at some cost.

The various technical-technological aspects of the ancillary facilities and the process of scheduling that we have just mentioned, affect no doubt the probability distribution surrounding the various degrees of utilization of the large tankers. The risk of underemployment is a function of the shape, mean, and variance of this distribution.

Although the probability of unscheduled delays due to breakdowns, weather, etc., and the consequent probability of interruption of the flow of oil to the refineries may be assumed to be the same for each vessel irrespective of size, and the probabilities surround the causes of these delays as well as the occurrences of delays per vessel over time and among vessels may be assumed independent but not mutually exclusive, yet the expected cost of a given time delay of larger vessels may be greater. The larger the vessel is, the greater will be the discontinuity of refinery operations, and the longer the duration of each idleness under the assumptions postulated above.

Variable X_1 represents this risk premium of underemployment. It operates both on the short term as well as the long-term rate and it obviously refers to the particularities of the chartered vessel. Since technology changes over time, we expect X_1 to be a function of the technological changes expected to occur over the charter duration.

The sign of the coefficient of X_1 is expected to be negative in our formulation because we take as a reference point for R_s the "marginal" vessels. For any submarginal or special purpose vessels the coefficient of X_1 is thus expected to be positive.

2. The Risk of Unemployment

Any vessel that operates in the spot market runs the risk of being unemployed a certain part of the year. This risk is not only due to frictional unemployment between the completion of contractual commitments[1] but also due to the particularities of the tanker markets. The particularities are conducive to fluctations where periods of surpluses are followed by periods of excess demand. Most of these factors are explained in detail in Reference [1].

[1] The common practice is for vessels to enter the market before the expiration of their commitment. Expections concerning the trend of rates will determine the exact timing but in general, for vessels trading in the spot market, the time difference between contract and vessel delivery is an increasing function of the spot rate and ranges between zero and fifty days. Normally, the vessel will enter the market at the time it leaves the loading point for the final leg of its trip.

The seasonality of the petroleum products accentuates further the risk of unemployment. In order to meet the requirements of seasons of peak demand, it is necessary to have over the year approximately 9 percent more transportation capacity, than what is necessary to meet the average demand. In other words, given the transportation requirements of any particular year, if these requirements were distributed uniformly over the year, the tonnage required to meet the demand would have been 91 percent of what is normally necessary to meet peak demand and this because the demand is not uniformly distributed. Between the peaks and valleys of demand for transportation capacity of each year, there is a difference of 13 percent of the average yearly capacity requirements. Unfortunately not very much can be done to smooth out shipments because the demand for fuel oil in winter months is not postponable. Consequently, although the capacity available at any moment of time may be sufficient to meet average yearly requirements, shortages and surpluses will appear over certain periods during any one year. Some oil companies fail to appreciate this risk, although they know that it exists. Always they plan on average yearly requirements and thus generate information that is biased.

We have chosen X_2 to represent the unemployment risk premium. This variable, unlike X_1 the risk of underemployment, operates only on long-term charters. Its coefficient is expected to be negative, because under a long-term charter agreement, the risks of unemployment are shifted to the charterer. The longer the duration of the time charter, the greater the reduction of the risk of unemployment facing the owner of a vessel.

B. Brokerage Fee Savings

On all transactions no matter whether these are for spot (single voyage), consecutive voyage or time charters, the brokerage fee is paid by the vessel owner. This fee is normally 1 1/4 percent of the total rental involved (called "hire") times the number of brokers taking part in the transaction. According to information obtained from industrial sources, most charters of all types are transacted through two brokers.

There are, of course, certain exceptions to these rules. For instance, the Japanese shipowners, who only recently entered the universal market, prefer to deal directly with the charterers (oil companies).

Turning to the number of brokers who enter into the transaction we find that most ship owners list their vessels with both London brokers, since London is the central tankship market, and Norwegian or United States (New York) brokers. As a result the fee paid is normally 2 1/2 percent of the charter hire and often goes as high as 5 percent.

Given that the fee is a function of the total revenue represented by the agreement, as long as the percentage is fixed, it makes little difference to the owner whether he enters the market only once or many times over the life of his vessel. Special arrangements are made, if the fee is large; it is spread over several months if not over the entire duration of the contract. So this consideration is not important from our point of view.

With the introduction of large tankers and charter agreements extending over 15-20 years, often special arrangements are made with the brokers and the fee may be reduced to as low as 3/4 percent. As a result we must make provisions in our formulation to reflect the impact of brokerage fee savings on the long-term rate. Variable X_3 is intended to represent these savings and its coefficient is expected to be negative since the brokerage fees are paid by the shipowners.

C. Ability to Borrow on Long Term Charter Agreements

A long-term charter agreement is very valuable for the owner of a vessel for another reason. It can be mortgaged. The steady income from the charter is used to liquidate the loan by being pledged as collateral. As a result the higher the rate and the longer the duration of the charter, the greater the "mortgageability" of the agreement. To the extent that we are concerned with the long-term rate in the long run and having taken care of the level of the rate in R_s', we need only deal with the impact of the charter duration on the long-term rate via the ability to borrow on the charter.

Because banks are not willing or anxious to commit funds for a period longer than five to seven years, a financing scheme has been devised where an insurance company accepts the mortgage beyond the 5th or 7th year, for a total of 12 years for the combined plan. A net hire which does not yield a present value equal to 75 percent of the cost of the vessel over 12 years is normally considered a bad risk and avoided. Especially if the charter agreement does not include escalation clauses for the costs that fall on the owner of the vessel. This does not mean, however, that a smaller loan may not be obtained.

In our formulation X_4 stands for the mortgageability of the long-term charters and its coefficient is expected to be negative.

D. Efficiency Premium of Vessels

In our model we took as a point of departure the normal rate of the marginal block of vessels. As a result, if we do not provide for the advantages of size, then our estimated long-run rate will be biased by the cost of the current marginal vessel.

We must therefore recognize that the more efficient a vessel is in terms of fuel consumption and speed, the greater the rate it will succeed in securing. Let us remember that an efficient vessel under a time-charter agreement benefits also the operator. The faster a vessel is the greater is its potential capacity, and the lower its fuel consumption the lower the total cost for the oil carried. Both these factors reduce the cost per ton of oil delivered, and as a result the time-charter rates for the efficient and faster vessels must be greater. In this way vessels of the same size, but of different speed and fuel consumption, by securing different rates tend to equalize the cost to the charterer per ton of oil delivered.

Because the charterer is not assuming any "risks" or is in any way inconvenienced if he charters an efficient vessel, we do not expect any part of the efficiency premium to revert to him. The added carrying capacity emanating through efficiency-reduced space taken by bunkers and more trips per year--although affecting the cost per ton delivered favorably, yet it is not of such a magnitude as to create invlexibilities of the nature covered by variable X_1. The coefficient of X_5 representing the efficiency premium is expected to be positive, if the long-term rate of our model is given in terms of dollars per DWT each month. If we translate everything in terms of spot-rate equivalent, however, then we do not need to provide for X_5 because the spot rate is expressed in dollars per ton of oil delivered and is equalized across the market. There is only one aspect of X_5 which operates in the long run irrespective of how the rate is expressed, and which we may wish to analyze. This aspect refers to the projected cost of fuel oil, and which we must reflect in X_5 since we are concerned with the long-term rate in the long run. We need to stress here that we are trying to simulate a rational and efficient market with stable expectations for the selection of the marginal ship. In this case we expect the coefficient of the efficiency difference between the marginal and the actual ship to be negative.

II. Methods of Measurement and Estimation of the Parameters of our Model

The normal spot rate R_s must reflect the risks of unemployment which affect vessels operating in the spot market. The expected unemployment E(U), characteristic of the spot market has three components:

(a) The expected unemployment because of tie-ups

(b) The expected idleness due to the seasonality in demand during any one year

(c) The hidden surplus" which is caused by "slow downs" and extended repairs

To facilitate our calculation of R_s we will assume that:

(i) The probability of idleness for any one vessel is uniformly distributed over the year.

(ii) The probability of idleness is uniformly distributed over the vessels operating in the spot market at any moment in time. We are interested here in the marginal capacity over time, consequently an assumption such as (ii) will not distort our calculations.

(iii) A specified run is given. We chose the Persian Gulf - W. Europe route (22,000 n. miles around the Cape) because it covers the largest throughput of oil. Based on References [2], [3], [4], we estimate the probability of unemployment $\hat{U}$ as a percentage of the fleet to be 3% for all sizes from 1970 - 1974; from 1975 - 1980 we estimated:

Size (DWT)	Less than 100,000	100,000-200,000	More than 200,000
U	4.0%	5.5%	4.5%

1. The Rate

The desired rate R_s is given by the following relation:

$$
\begin{aligned}
K_d = & \sum_{t=1}^{20} [(1 - \hat{U})\ C_m(t) R_s - OC(t)]\ (1+i)^{-t}\ (1-TR) \\
& - \sum_{t=1}^{20} MP\ (1+i)^{-t} \\
& + \sum_{t=1}^{20} MP(t)\ (1+i)^{-t}\ TR \\
& + \sum_{t=1}^{20} D(t)\ (1+i)^{-t}\ TR \\
& + S_n (1+i)^{-20} \\
& + [I - \sum_{t=1}^{20} D(t) - S_n]\ (1+i)^{-20}\ TR
\end{aligned}
$$

In the above formulation:

K_d = The down payment

$1-\hat{U}$ = The probability of employment, $\hat{U}$ being the estimate of U as previously explained

$C_m(t)$ = The yearly carrying capacity

R_S = The unknown rate in terms of $/ton delivered that we are looking for

$OC(t)$ = The yearly out-of-pocket operating costs which may be a function of time and include:

(a) Wages, Salaries and Supplies for the crew

(b) Insurance

(c) Maintenance

(d) Cost of Inspection

(e) Fuel cost and port charges.

These costs have been estimated from References [2], [3], [4], [5], [6] [7], [8], [9], [10], [11].

t = The time which ranges from one year to 20 years, the life of the vessel

i = The owner's cost of capital which in our case is 11 percent per year from 1970 to 1974 and 14 percent per year from 1975 - 1980.

TR = The income tax rate, taken as a weighted average of the tax rates of the major shipping countries, Reference [12].

MP = The yearly payments for liquidation of the loan. These are assumed to be constant per year and include both capital and interest

MP(t) = The interest part of the yearly payments which is a decreasing function of time

D(t) = The yearly depreciation for income-tax purposes which is a function of time unless the straight line method of deprection is used.

S_n = The scrap value of the vessel at retirement n years from building it.

I = The total cost of building the vessel

Since our formulation starts at a fixed point of time and determines R_s for the marginal ship, it may be advisable if we include any changes in R_s which may occur over time due to technological change, see Table [1]. Change over the duration of the charter will affect expectations. Hence we calculate the spot rate R_s at two points in time: at the transaction point, R_s' and at the termination of the charter, R_s^n. We then use in our program an average spot rate, R_s^*, given by

$$R_s^* = \frac{1}{n} \int_0^n [R_s^n + (R_s' - R_s^n) \; e^{-jt}] \, dt$$

To obtain j we may set

$$e^{-jn} = .05 \text{ or } .10$$

where n = duration of charter in years

2. Estimation of X_1: the Risk of Underployment

The risk of underemployment X_1 is a function of size. Consequently, X_1 must reflect the amount of the economies of scale that is conceded to the charterer.

Instead of introducing merely size in X_1 which will give the variable static characteristics (fixed point), X_1 is measured in terms of cost savings. Taking the marginal vessel size as a point of departure, we calculate the savings that accure with size, express them in terms of $/ton of oil delivered and we assign this value to X_1. Obviously these calculations are intended to give us a flexibility in determining the long-term rate in the long-run. If we set $X_1=0$ then we obtain the normal long-term rate and if we base the value of X_1 on the difference between the cost of the marginal vessel and that of size S^*, then we are deriving a particular long-term rate.

In order to obtain these cost savings for any given size of vessels, we calculate R_s for both the marginal vessel and the vessel under consideration and solve for the difference between the two short-term rates R_S. Since we are not concerned with any other economies but those of size we must exclude from the operating costs fuel consumption and also eliminate speed and propulsion differences. Hence

$$X_1 = 1/n \int_o^n [ES_n + (ES_o - ES_n) e^{-\rho t}] dt$$

where

ES_0 = The economies-of-scale advantage of the vessel to be chartered over the marginal vessel at the point of the charter transaction.

ES_n = The economies-of-scale advantage of the chartered vessel over the vessel expected to be marginal at the point of termination of the charter, n periods hence. To obtain

X_1 we may set

$$e^{-\rho n} = 0.05 \text{ or } 0.10$$

where n = duration of charter in years.

We must stress once again that if one wishes to derive the <u>normal</u> long-term rate, then he must set $X_1 = 0$, and that in agreement with the dimension of the long-term rate, X_1 is the average risk premium due to underemployment over the duration of the charter agreement.

3. <u>Estimation of X_2: the risk of unemployment</u>

The risk of unemployment has been already found in the process of determining R_s. We noticed that for vessels operating in the spot market, the probability of unemployment reduces capacity by a factor $\hat{U}$. Under certainty of employment, the capacity realized is C_m and not $(1-\hat{U})C_m$, consequently the rate that is required to guarantee a fair return after taxes now becomes $R_s^* = \frac{\text{certainty rate}}{1 - \hat{U}}$. The difference between these two rates, which is $\hat{U}R_S^*$, reflects the value of the unemployment risk and will serve as an estimator of X_2.

Although the risk premium due to unemployment is a function of the absolute size of the charter agreement yet we do not have to allow for any such functional relation. And this because $R_S^*(1-\hat{U})$ is in terms of \$ per ton of oil delivered and applies to each and every year the vessel is on time charter. There is another aspect of X_2 that we must consider, however, and this relates to the duration of the charter agreement. In order to preserve the flexibility of our model and in accordance with our treatment of X_1 we made X_2 a function of time. If we assume that the more immediate the security the more important it is, then we must provide for an exponential decay of the uncertainty premium with time. The mathematical formulation that we need in this case must be an increasing function of duration but must give decreasing returns to scale because beyond a certain number of years the marginal contribution to security of an added year of time-charter duration is indeed of little value.

So for any charter the value of X_2 will be:

$$X_2 = R_s^* \; U \; (1 - e^{-\alpha n})$$

where n = charter duration in years

to obtain X_2 we may set

$$e^{-\alpha 15} = 0.05 \text{ or } 0.10.$$

4. Estimation of X_3: the savings of brokerage fees

We will assume here that 2 1/2 per cent of the total rental involved in a transaction is the normal brokerage fee for spot charters. We will also assume that the minimum brokerage fee is 3/4 per cent. These quantitative limits have been obtained from oil companies.

Since the hire H is H = f(nxS), that is to say a function of both the charter duration and the size of the vessel, the exponent of asymptotic convergence must take both into consideration. We will therefore assume that the savings in brokerage fees reach a maximum when both the duration of the charter approaches 15 years and the size of vessel 500,000 DWT.

One expression for X_3, which assumes logarithmic proportionality with respect to charter duration and vessel size (increasing returns to scale with n and S) is as follows:

$$X_3 = \frac{(0.0175)^{\alpha \cdot n + \beta \cdot S}}{\sum_{t=1}^{n} C_m(t)}$$

where $\sum_{t=1}^{n} C_m(t)$ represents the carrying capacity over the duration of the charter. To derive α and β we observe that the maximum savings can be (0.0175) H.

To obtain α and β we set $\alpha.15 = 75$ and $\beta.500 = .25$

The choise of the weights for n and S was dictated by the way H varies with respect to t and S. The range of n, the charter duration, is from 1 to 15 with every year doubling the yearly hire. Size, however, increases approximately by a factor of only five from the size of the marginal vessel today to 500,000 DWT. Hence the weights of 3 to 1.

The fact that there is a probability of unemployment $\hat{U}$ for vessels operating in the spot market does not dictate any adjustments, because the rate under uncertainty R_S^* is higher than the expected certainty equivalent $R_S^* (1-\hat{U})$. As we have already explained, the brokerage fee is a function of the total charter hire which is a product of the time duration of employment and the rate, given a vessel size. Consequently whether we have the product of reduced capacity $C_M(1-\hat{U})$ and R_S^* versus full capacity C_M times reduced rate $R_S^* (1-\hat{U})$ the result remains unchanged providing complete compensation on this score.

5. Estimation of X_4: the loan value of the long term charter agreement

In order to measure X_4 we must make certain assumptions concerning the two polar alternatives. It seems logical to assume that no vessel will be built unless it can secure some type of a loan. We must notice that this assumption is not overly restrictive. If the potential owner is an independent with well established position in the industry, then the probability that he will be refused a loan is small. On the other hand given that his cost of capital is greater than the borrowing rate, the probability that he will refuse to take advantage of loan arrangements will likewise be small.

The two polar sets of provisions that we will assume are:

	Restrictive Plan-- No time Charter Pledged	Liberal Plan-- Time Charter of 12 years as Collateral
Down Payment as % of total cost	30%	15%
Duration of loan in years	8.5 ('70 - 74)	7.5 ('70 - 74)
Interest rate compounded yearly (%)	11.5 ('75 - 80)	10.5 ('75 - 80)

Give the above two alternatives, we can then find the value of each different plan to the owner by discounting the various payment streams at the owner's cost of capital.. The total difference between the two we can then divide by the total capacity of the vessel over its life-time (20 years) and find the maximum loan value of the charter in terms of $ per ton of delivered oil capacity.

The difference in X_4 between vessels will be due to economies of scale. But the latter which affect the necessary investment per unit of capacity, we have already considered in X_1 and will consider one remaining aspect in X_5. So for our purposes here X_4 is independent of size. We must however make X_4 a function of the length of the time charter. Hence

$$X_4 = V^L_R \ (1-e^{-\delta n})$$

where V^L_R = the difference between the liberal and restrictive plan, n = time charter duration in years.

To find the value of δ we may set:

$$e^{-\delta 12} = 0.05 \text{ or } 0.10$$

6. Estimation of X_5: the efficiency premium

If we now look at vessels of different sizes still at any fixed point in time and for charters of the same time duration, we are confronted with three consequences of size as these affect efficiency. These are:

1. Economies reflected in decreasing costs of shipbuilding per DWT of capacity.
2. Economies reflected in increases in transportation capacity more than proportional to increases in deadweight tonnage.
3. Inflexibilities of size as previously explained.

Of all the above factors, the first one is reflected in R^*_S so we need not provide for it here. The process of translation of long-term rates, in terms of $ per ton of oil delivered, will take care of the second factor. Finally, the third factor has been considered in X_1 so it need not concern us here. We see, therefore, that all aspects of the efficiency premiums for vessels of all sizes at any fixed point of time have been properly considered.

Finally we look at the efficiency premiums over time and find that there is one aspect that merits consideration, and it refers to the operating costs. Of the latter, two stand out in particular, crew costs and fuel oil costs.

To the extent that the operating costs falling upon the owners of vessels chartered on a time basis are considered in detail in R_S^*, there is no further need for adjustmentsat this point. For the fuel oil, however, we must recognize any trends in future prices. Since the charterer pays for the oil fuel, the more efficient the vessel is the more he stands to benefit over the life of the time charter if prices increase and vice versa. We have to stress again that the point of departure in our model is the spot rate R_S^* of the marginal ship. The partial effect of fuel price increases is manifested more clearly if we consider the case of a vessel similar to the marginal ship, but slightly more efficient in terms of fuel consumption. It can be easily proved that since everything else is equal and X_1 takes care of improved capacity, the relevant spot rates R_S^* will be equalized only if the relatively efficient vessel gets a premium over time, X_5. We expect its coefficient to be negative.

$$X_5 = \frac{1}{20} \sum_{t=1}^{20} (R_f^* - R_f^a)\,(1 + \eta)^t\,(1 + i)^{-t}$$

where R_f^* = = spot rate equivalent of fuel costs in \$/DWT for the average marginal ship during the charter period

$$= \frac{1}{n} \int_o^n [R_f^n + (R_f' - R_f^n)\, e^{-jt}]\, dt$$

R_f', R_f^n = spot rate equivalent of fuel costs in \$/DWT for the marginal ship

R_f^a = spot rate equivalent of fuel costs in \$/DWT for the actual ship

η = per cent growth (decline) of fuel prices

i = owner's cost of capital

III. Computer Modeling - Statistical Results

We developed a computer model to simulate the market conditions that prevailed in the tanker market during the years 1970 - 1980. An extensive data base was created which covers the size distribution of the marginal vessels, over the years. Operating costs (OC), Fuel Costs (FC), port charges (PC), and shipbuilding costs (SC), are also included in the data base.

Costs were gathered from various sources but were elaborately cross-checked for consistency and validity. The basic parameters were DWT, year of construction, wages, supplies, insurance, maintenance and repairs, flag and fuel consumption.

We built in the model coefficients of growth for operating, fuel and construction costs as well as port charges. We carefully qualify, though, for expectations; our model is a simulation and forecasting model, but does not explicitly include market expectations. A thorough analysis of the effect of expectations is given in Reference [1]. We were also cautious in the use of the cost/growth coefficients. They were structured so as to change over the years. In the 1970 - 1980 decade we used:

	1970 - 1973	1974 - 1976	1977 - 1980
Growth of OC	7%	10%	20%
Growth of FC	11%	15%	20%
Growth of PC	6%	9%	14%
Growth of SC	13.6%	13.6%	13.6%

A second data base was created which includes all the time charter transactions during the years September 1970 - 1980. We have incorporated the date, DWT, speed, fuel consumption, charter duration, lead time and time charter rate as were in the reported transaction in References [13] [14]. A few discrepancies were corrected through other sources.

Our program enters first data base at two points in time: the time of transaction and the time of termination of the charter. Then it augments these data with data from the second data base for actual transactions. Hence the variables R_s', R_s^n, R_s^*, R_f', R_f^n, R_f^*, X_1, X_2, X_3, X_4, X_5 are calculated as described in II. Finally the unweighted long-term rate R_L in the long run is determined as a simple sum of R_s^* and the Xi using the appropriate signs. Along the way all costs and rates are calculated on a spot-rate equivalent basis.

Two models were employed: a linear one and a log-linear one. The linear model showed very little difference with the log-linear model in terms of significance of coefficients and variance explanation (R^2). We therefore chose to present the results of the linear model, along with correlations of the variables and t-statistics (in parentheses). Our results are presented in Tables 2 through 12.

IV. Conclusions

As we have already discussed that the actual spot rate may reflect some market imperfections in the short-run and most importantly market expectations. Expectations are not treated by our model, as they are not treated by most of the economic forecasting models. We provide, however, a benchmark against which executives can base a long-term strategy.

In a fashion similar to the Capital Asset Pricing Model we developed the long-term rate as the market return plus or minus risk premiums. We calculated risk premium through an industrial economics/strategic approach instead of blindly using covariations with the market as a surrogate for systematic risk.

Our results, shown in Tables [2] through [12], verify some of our hypotheses and reject some others. Starting with R_s^* we observe that it is significant in 1970, 1971, 1976, 1978 at 90%. Its coefficient, however, presents a startling change of sign in 1976, 1977, 1978. We tried to check for this puzzle by stratifying our data in terms of "high" actual spot rates and "low" actual spot rates (above and below World Scale 100 respectively). Our results for the "low" period 1975 - 1980 showed that R_s^* still has a negative sign.

There is, however, a plausible explanation to this: as normal spot rate tended to go lower during this period of very depressed rates, owners expected that soon a period of high rates will emerge. Hence they asked for higher long-term rates in order to be compensated for their opportunity cost of the forthcoming "boom". It shows that when situations are not "normal",, i.e. when short term expectations govern, long term rates are also influenced.

The most significant variable though proved to be X_1 , the risk premium for underemployment. It was significant in 1970, 1972, 1973, 1974, 1975, 1976, 1977, 1979, 1980. It seems that owners hurt very much when they use their ship partially loaded. Another aspect of X_1 is that we introduced economies of sale accruing from technological change in the formulation of the underemployment premium. During the early seventies the size of oil tankers increased dramatically pushing smaller vessels out of the market. The echo from this impact was still heard through the whole decade, as the significance of X_1 implies.

Surprisingly the coefficient of X_2 , the premium for unemployment was almost insignificant, except in 1970, 1973, and 1978. Our formulation of $\hat{U}$ includes historic averages which do not incorporate expectations and also artificially smooth out the pattern of laid-up vessels. We should take into account that 1970, 1973, were years of "high" actual spot rates and 1978 was a year of upward moving actual spot rates. We may postulate that owners expected this phenomenon to be short lived and conceded some of their benefits to insure themselves from the coming "lean" days.

The premium for brokerage fee savings was consistently insignificant and numerically very close to zero. Owners apparently do not concede anything to alleviate this risk, because from a strategic point of view market and financial risks are much more important.

The mortgageability X_4 of secured time charter rates proved to be significant in 1970, 1971, 1973, 1976 and 1979. Apparently the higher the rate the more valuable it is for mortgage purposes. Shipbuilding cycles have a certain lag from the actual spot rate cycles and it is quite difficult to correlate the two of them. This complicated pattern is explicitly handled in Reference [1].

Finally the fuel efficiency premium X_5 was insignificant and close to zero in the years before 1974. Since then has been significant to highly significant (1975, 1976, 1977, 1978, 1979, 1980). We expected this result because the prices of bunkers, high viscosity fuel and diesel oil has more than quintupled since then.

The second set of regressions, namely spot equivalent of the actual time charter rate vs the simplified long term rate R_L gave consistently significant coefficients. The proximity of these slope coefficients to 1.00 shows that R_L approximates the actual rate successfully, with the exception of a constant error. Probably the introduction of the actual spot rate in the model would explain this discrepancy over time.

It should be noted that all our R^2 are very satisfactory and some of them are exceptionally good, (1972, 1974, 1975, 1976, 1977, 1979 are above 80%).

In Figures 1(a) - 1(c) and 2(a) - 2(c) we have plotted the actual time charter rates, the model (regression) time charter rates and the unweighted simulation rate R_L vs the DWT. We present only 1973 and 1977, because they are representative of the results we got from 1970 - 1980.

It is very interesting to not that our simulation rate R_L constitutes the efficient frontier of the traditional, rational economic theory with stable expections. In 1973 when spot rates were high and market expectations were unstable we observe from Figure 1(a) and 1(c) that "efficient" ships were used only. Finally Figures 1(b) and 2(b) prove that our simulation model-regression analysis time charter rate adequately predicts the actual time charter rate. On-going research has recently showed us that our simulation model-regression analysis accurately predicts the actual time charter rate, even in periods of high spot rates, when expectations are incorporated into the model.

Year	DWT	Operating Costs $/DWT/year	Fuel Costs $/DWT/year	Port Charges $/DWT/year	Total Operating Costs $/DWT/year
1970	40,000	15.9847	6.2602	0.7923	23.0372
1971	50,000	14.8308	7.2680	0.8713	22.9701
1972	60,000	14.1696	8.0089	0.6408	22.8193
1973	60,000	16.0167	12.0251	0.6408	28.6826
1974	87,000	13.8968	29.3489	0.5359	43.7816
1975	87,000	15.4187	31.0127	2.4883	48.9197
1976	125,000	12.7797	24.3458	2.4957	39.6212
1977	125,000	15.7037	27.1863	2.7668	45.6568
1978	140,000	16.4979	25.6342	2.9842	45.1163
1979	140,000	17.3843	38.0618	3.3366	58.7827
1980	150,000	19.5202	44.7239	3.6501	67.9062

Table 1 Size Distribution and Total Operating Costs of the Marginal Vessel

1970 - 116 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = -14.114 + 4.328 R_s^* - 0.709X_1 - 163.700X_2 - 0.000X_3 + 191.200X_4 + 0.975X_5$

(8.19) (3.29) (-6.18) ( ) (6.92) (0.76)

R^2 = 88.0% adjusted for d.o.f.

b) $Y = 5.964 + 1.015 . R_L$

(9.810)

R^2 = 45.3% , adjusted for d.o.f.

Table 2

1971 - 112 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = -50.781 + 6.691R_s^* + 0.576X_1 + 4.761X_2 - 0.000X_3 + 219.3X_4 + 0.888X_5$

(5.19) (1.47) (0.11) ( ) (4.33) (0.81)

R^2 = 47.2%, adjusted for d.o.f.

b) $Y = 3.651 + 0.981 R_L$

(7.62)

R^2 = 34%, adjusted for d.o.f.

Table 3

1972 - 76 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = 4.980 + 0.294R_s^* - 0.898X_1 + 9.970X_2 - 0.000X_3 - 4.880X_4 - 0.000X_5$

(0.83) (-9.81) (1.40) ( ) (-0.46) ( )

R^2 = 84.8%, adjusted for d.o.f.

b) $Y = 2.501 + 0.733 R_L$

(17.11)

R^2 = 79.5%, adjusted for d.o.f.

Table 4

1973 - 200 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = 12.900 + 0.277\ R_s^* - 0.780X_1 - 48.1X_2 - 0.000X_3 + 17.900X_4 - 0.000X_5$

(0.41) (4.58) (-3.53) ( ) (1.71) ( )

R^2 = 66.8%, adjusted for d.o.f.

b) $Y = 3.269 + 1.036\ R_L$

(18.451)

R^2 = 63.1%, adjusted for d.o.f.

Table 5

1974 - 70 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = 0.0897 + 1.250\ R_s^* - 2.650X_1 - 26.800X_2 - 0.000X_3 + 44.200X_4 - 0.000X_5$

(1.43) (-11.11) (0.71) ( ) (0.77) ( )

R^2 = 90.4%, adjusted for d.o.f.

b) $Y = -15.846 + 2.676\ R_L$

(23.11)

R^2 = 88.5%, adjusted for d.o.f.

Table 6

1975 - 127 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = -15.610 + 2.200\ R_s^* - 1.969X_1 + 11.100X_2 - 0.000X_3 - 12.200X_4 - 0.287X_5$

(0.51) (-9.18) (0.83) ( ) (-0.25) (-3.86)

R^2 = 95.5%, adjusted for d.o.f.

b) $Y = 1.2.580 + 0.695\ R_L$

(14.53)

R^2 = 89%, adjusted for d.o.f.

Table 7

1976 - 112 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = 38.4 - 2.572\ R_s^* - 1.178X_1 + 8.590X_2 - 0.000X_3 - 25.8X_4 - 0.482X_5$

(-3.10) (-10.50) (1.50) ( ) (-2.53) (-9.24)

R^2 = 93.0%, adjusted for d.o.f.

b) $Y = 2.07 + 0.693\ R_L$

(30.411)

R^2 = 89.3%, adjusted for d.o.f.

Table 8

1977 - 52 observations

Y = spot equivalent of time charter rate ($/DWT)

a) $Y = 28.7 - 1.710\ R_s^* - 1.430X_1 - 2.426X_2 - 0.000X_3 + 20.600X_4 - 0.276X_5$

(-1.22) (-7.86) (-0.39) ( ) (0.96) (-1.74)

R^2 = 95.3%, adjusted for d.o.f.

b) $Y = 0.368 + 0.939\ R_L$

(21.520)

R^2 = 90.1%, adjusted for d.o.f.

Table 9

1978 - 43 observations

Y = spot equivalent of time charter rates ($/DWT)

a) $Y = 106.520 - 7.600\ R_s^* - 0.400X_1 - 40.100X_2 - 0.000X_3 + 29.2X_4 - 0.584X_5$

(-1.85) (-0.91) (-2.16) ( ) (0.75) (-1.69)

R^2 = 77.6%, adjusted for d.o.f.

b) $Y = 3.4 + 0.660\ R_L$

(11.440)

R^2 = 75.6%, adjusted for d.o.f.

Table 10

1979 - 95 observations

Y = spot equivalent of time charter rates ($/DWT)

a) $$Y = -2.610 + 1.190\,R_S^* - 1.22X_1 - 19.000X_2 - 0.000X_3 + 56.000X_4 - 0.576X_5$$
$$\quad (0.62) \quad (-4.29) \quad (1.46) \quad (\quad) \quad (1.83) \quad (-2.95)$$

R^2 = 84%, adjusted for d.o.f.

b) $$Y = 2.45 + 1.000\,R_L$$
$$(20.790)$$

R^2 = 82.1%, adjusted for d.o.f.

Table 11

1980 - 52 observations

Y = spot equivalent of time charter rates ($/DWT)

a) $$Y = -17.260 + 2.110\,R_S^* - 1.107X_1 + 16.5X_2 - 0.000X_3 - 4.470X_4 - 0.734X_5$$
$$\quad (0.59) \quad (-2.77) \quad (0.50) \quad (\quad) \quad (-0.08) \quad (-3.41)$$

R^2 = 79%, adjusted for d.o.f.

b) $$Y = 7.105 + 0.898\,R_L$$
$$(14.05)$$

R^2 = 79.4%, adjusted for d.o.f.

Table 12

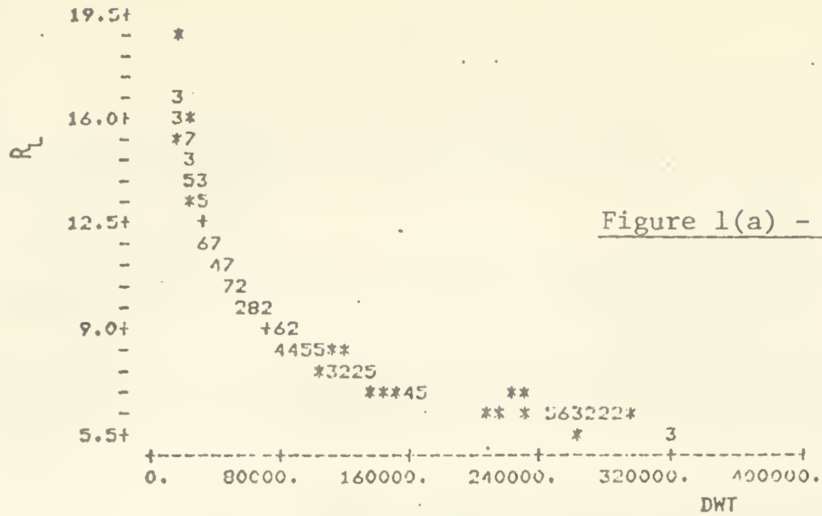

Figure 1(a) - 1973

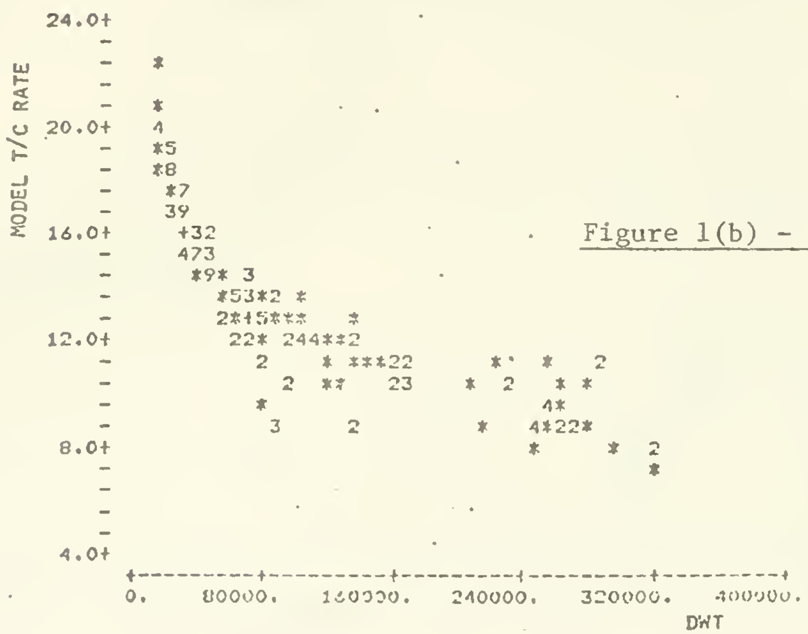

Figure 1(b) - 1973

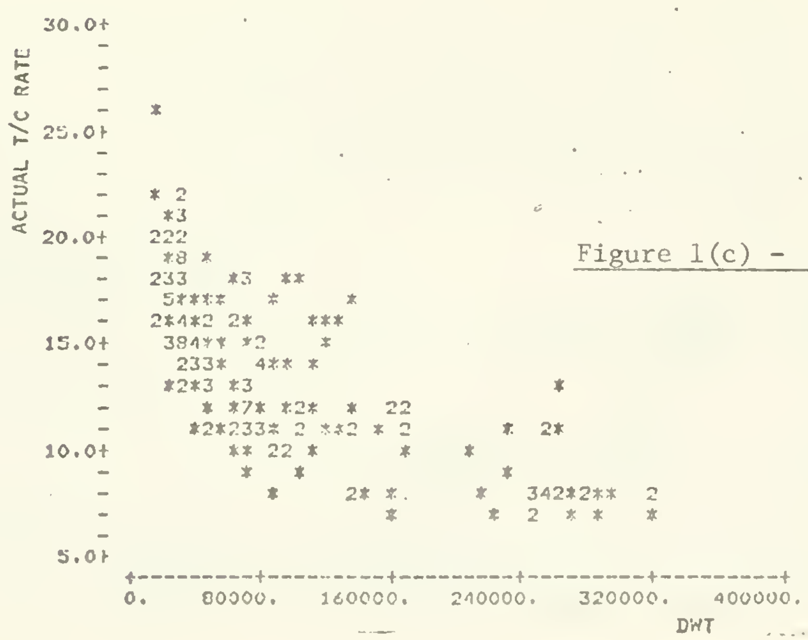

Figure 1(c) - 1973

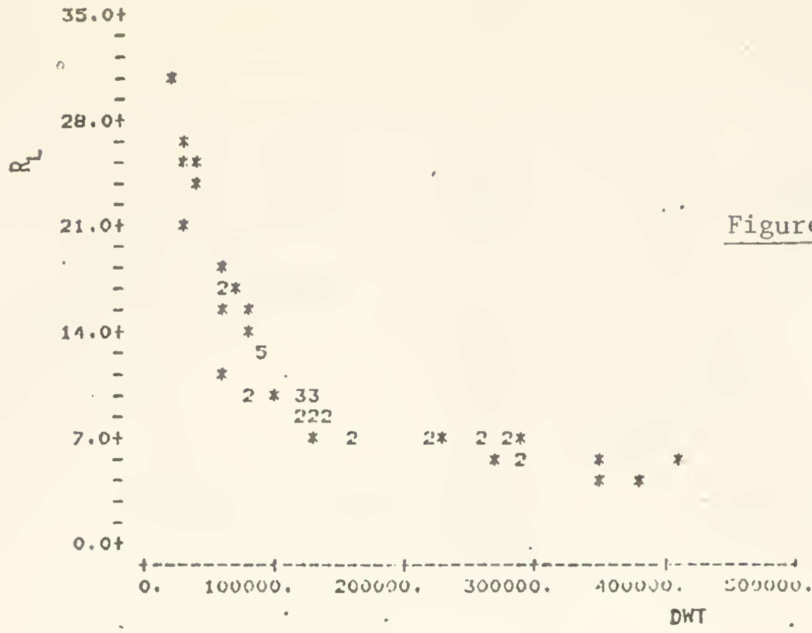

Figure 2(a) - 1977

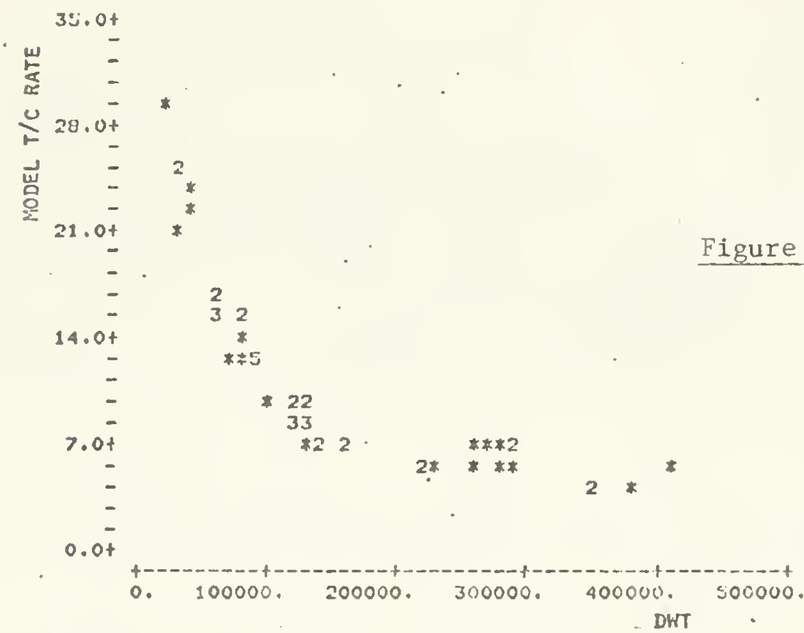

Figure 2(b) - 1977

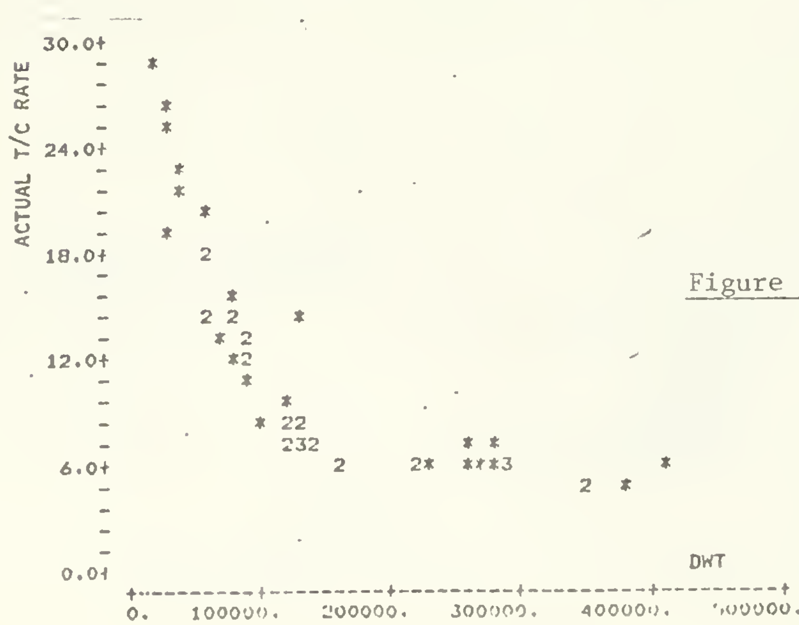

Figure 2(c) - 1977

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