THE THEORY OF OIL TANKSHIP
RATES: AN ECONOMIC ANALYSIS
OF TANKSHIP OPERATIONS
84-64
Zenon S. Zannetos
Preface

This study is based on my doctoral dissertation and subsequent related research that I conducted in the area of tankship transportation economics. The essential characteristics of the tankship markets, and the factors that influence the behavior of tanker owners and tanker charterers, have not changed since 1959 when I submitted the dissertation to the Department of Economics at the Massachusetts Institute of Technology. Intervening events provided further evidence that the conclusions reached then are based on fundamental interrelationships of general applicability and which can stand the test of time.

My interest in the area of tankship rate formation started in the spring of 1956, and was stimulated by Professor Morris A. Adelman who became chairman of my thesis committee. To him, and Professors Charles P. Kindleberger and Robert M. Solow, the other members of the committee, I wish to express my great appreciation for their guidance.

To those who assisted me with the original manuscript I once again acknowledge my gratitude. In particular I wish to thank Professor Gordon Shillinglaw, now at Columbia University, and Miss Miriam Sherburne of the Sloan School of Management of the Massachusetts Institute of Technology who offered helpful criticism and suggestions on organization and form.

The Sloan School of Management of the Massachusetts Institute of Technology supported part of the cost of data collection and processing with a grant from the Sloan Research Funds, and the Massachusetts Institute of Technology Computation Center allotted computer time to my research project for many statistical calculations and tests. To those responsible for this aid go my sincere thanks.
The amount and diversity of statistical information supporting this study is quite extensive. The task of collecting this information was extremely complicated because for the major part relevant data are not publicly available. Oil companies collect some data for their internal purposes but often consider what they have as proprietary. Moreover the information that is available in any one place is usually segmented or specialized, and cannot be readily put together into meaningful time series. It is for all these reasons that I am so appreciative of the assistance I received and continue to receive from industrial sources in my research efforts. A list of those who benefited this study includes executives of oil companies, shipyards, banks, tankship transportation companies, tankship brokerage firms, canal and pipeline companies, tanker owners and operators, government agencies, and numerous firms related to the oil industry and spread all over the world. Above all, however, I wish to thank Messrs. A. J. Kelley, Jr., J. O. Williams, and F. E. Albrecht of the Transportation Co-ordination Department of the Standard Oil Company (New Jersey), who made available to me their wealth of data and knowledge.

Finally, I wish to thank those who toiled most with the finished product: Miss Geraldine Weidman who typed most of the manuscript and who cheerfully and efficiently handled all the details of reproduction showing an immense pride in the final outcome, Mrs. Laurel Townsend, Jr., who expertly assisted with the typing, and my wife whose beneficial influence has permeated throughout the manuscript from beginning to end.

Cambridge, Massachusetts

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Chapter I

Introduction

Static economic theory states that, given a particular stage of technological development, individual preferences, and resources at a moment of time, all prices in the economic system will be forced to levels at which all markets reach equilibrium. All the adjustments that are necessary for such an equilibrium occur instantaneously and, at the equilibrium price, all the markets are cleared.

In the real world not only do adjustments take time to occur but also the markets are not cleared. A stable equilibrium is achieved in some cases; but only for very short periods of time, and the quantities supplied and demanded are a function not only of current, but also of expected, prices. As Hicks explains, the current supply of a commodity "depends not so much upon what the current price is as upon what entrepreneurs have expected it to be in the past. It will be those past expectations, whether right or wrong, which mainly govern current output."\(^1\) Similarly, past as well as future expectations determine the position of the current demand curve of a commodity.

The significance of the role of expectations in price determination is very evident in the tankship markets. Very few prices of commodities fluctuate as violently as the spot tanker rates, mainly because of the present impact of actions which have been initiated in the past by

expectations as to what conditions would be in the future. In particular, short-term supply and demand relationships determine the spot rate in the tankship markets. The spot rate, in turn, greatly influences expectations about the future course of events. This relative price elasticity of expectations\(^1\) influences the number of orders for new ships on the supply side. It also shifts the demand to the right during periods of high rates, as users of tankers rush to secure tonnage, and to the left during periods of low rates, as users withdraw from the market. One can readily see that the combination of the above factors creates essential interrelationships between the supply and demand schedules of one period with those of another, and that it also generates circular interdependence between supply and demand.

If tankers were a perishable commodity or a ready substitute for other commodities, the impact of misguided expectations would be short-lived, although not mild. But such is not the case. Tankers have an economic life of at least 25 years on the average and cannot be used for any important purpose other than the shipment of crude oil and its products, except possibly for transporting grain and ore, which can only be done at a relatively high cost.\(^2\) What is more, the demand schedule for tankers (being

\[ \frac{\Delta P_f}{P_f} \left( \frac{P_o}{\Delta P_o} \right) > 1 \]

where \( P_o \) and \( P_f \) stand for present and future (expected) prices respectively and \( \Delta P_o \) and \( \Delta P_f \) represent changes in present and future prices.

\(^1\) We say that price expectations are elastic if

\(^2\) Westinform Service estimates that it costs about $30,000 to $35,000 for cleaning the tanks of a vessel of 16,500 DWT. and in addition there are costly delays in loading and unloading because the pumping equipment of tankers cannot be used in such trades. W. G. Weston Ltd., London, letter to the author dated March 3, 1959.
a derived demand schedule) exhibits considerable price inelasticity over the
greatest part of the relevant price range. A drop in rates, therefore,
cannot possibly absorb any excess tonnage,¹ nor would an increase in rates
bring about a reduction in the quantities demanded except at a very high
rate level.² This relative rate insensitivity of the quantities supplied
and demanded, is due to the fact that there is virtually perfect comple-
mentarity between delivered (imported) oil and tankers.

The purpose of this manuscript is to contribute toward the development
of a theory of oil tankship rates. Efforts will be made to identify all
the factors that affect the rates in the short run as well as the long
run, and wherever possible estimate their impact. Since rates are the
rental of tankships, in the process of studying the determinants of tank-
ship rates we shall devote a considerable amount of effort on the economics
of tankships.

¹Because of the role that the oil companies are performing in generat-
ing the demand expectations and also in supplying a significant portion
of the tonnage requirements, the companies aggravate the fluctuations in
rates. During periods of high rates they are usually short of tonnage to
meet their requirements and during periods of distress the oil companies
enter the market not as buyers but as sellers of their excess capacity.
This is similar to Giffen's paradox, but the symmetry is not real,
because in the case of tankers we are not dealing with inferior goods.

²This high level for an input to a commodity is, as Marshall says,
"limited by the excess of the price at which that amount of the commodity
can find purchasers, over the sum of the prices at which the corresponding
supplies of the other things needed for making it will be forthcoming."
1956, p. 317. Within the context of our discussion the "commodity" may
be taken as delivered oil and the other supplies, crude oil or products.
The transactions in the tankship markets can be classified into two general categories, the spot, or single voyage, and the period, or long-term, transactions. The rate for single voyage charters is expressed in terms of a monetary consideration (let us say "dollars") per ton of oil delivered, but the long-term charter rate is usually expressed in terms of "dollars" per deadweight ton (DWT) per month.

The period, or long-term, charters may refer to either a vessel that is maintained and furnished by the owner with crew and provisions--except for fuel, port charges and tolls--or to a "bare" boat which the charterer furnishes and maintains. Because the "bareboat" charters constitute less than 1% of all the long-term transactions, the terms "period," "long-term" and "time" will be used interchangeably and will exclude bareboat charters.

In between the single voyage and the time charters, we find the "consecutive voyage" charters. As the name implies, consecutive voyage charters have all the characteristics of the single voyage charter, but the contract is for either a specified number of such voyages or as many voyages as can be arranged within a given time period. Although not significant in the past, this form of charter seems to be gaining in importance.

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1Note that the term spot is a technical term and in the common industrial usage means single voyage. It does not distinguish "futures" from "non-futures" transactions. Both single voyage and long-term charter agreements may either specify immediate or future delivery. Because contracts for single voyages usually specify "immediate" delivery, the term spot acquired a one-sided connotation, and unless it is qualified it implies current rate for a single voyage. It is also for this reason that "short term" is defined as the time it takes a vessel to complete a round-trip voyage for a specified run.
The oil companies now own less than 40% of the total tonnage of vessels of 6,000 DWT. and over. The companies claim that they attempt to supplement their ownership with vessels chartered on a long-term basis, to a total of 90% of their expected requirements. For the remaining 10%, they choose to depend on the spot market.

In an expanding industry such as oil, errors in forecasting transportation needs are to be expected. The trouble is that even a small error in the aggregate demand, may necessitate adjustments that generate serious disturbances in a spot market that encompasses no more than approximately 15% of the total capacity. We must remember that at any moment of time the available supply is in the spot market. As a result an error of only 5% in the total transportation needs of the industry will be equivalent to 100% of available capacity, if only 5% of the total fleet operates in the spot market. Given inelastic demand, heavy opportunity costs, expectations of elasticity different from one, and adjustments that are not instantaneous, the spot rates may fluctuate violently. It appears that this is what has happened historically.

As in any investigation of the factors affecting the price of a commodity, we shall examine the economic data that enter into the determination of the supply and demand schedules of tankship capacity. However, unlike purely theoretical analyses of this sort, which assume a distinct dichotomy between static and dynamic considerations, an empirical study must face the difficult problems of identifying rather than distinguishing a priori between these two types of phenomena. As Professor Kaldor said in his critique of Mrs. Robinson's celebrated book,1 "the apparatus of the 'curves' becomes

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progressively less useful as one makes the basic assumptions more realistic, since it become increasingly difficult to exhibit the conditions of equilibrium by functions of one variable.\textsuperscript{1} While in theory we can assume other things equal, in practice we are not afforded the pleasure of holding constant all variables but one, so that we can measure the impact of this one. However, static analysis does aid us in understanding the working mechanism of economic forces.\textsuperscript{2} The comparison is made here in order to point out how easy it is to mistake movements along a given demand schedule for temporary equilibria established after the relevant schedules themselves have shifted. Given the existence of shifts, it is, in general, impossible to determine the slopes of the traditional demand and supply curves.\textsuperscript{3}

In the process of investigating the factors which enter into the determination of rates, we shall follow for convenience the tradition of first discussing separately the factors operating through the respective demand and supply schedules. We shall then fuse the two schedules and show how short-term rates are determined.

Once the discussion on the determination of the spot rate is completed, attention will be focused on the long-term, or period, rates. In this

\textsuperscript{1}"Economics of Imperfect Competition," \textit{Economica}, Vol. 1, Numbers 1-4, 1934, pp. 336-337.

\textsuperscript{2}As Lionel Robbins said on a slightly different occasion in his "On a Certain Ambiguity in the Conception of Stationary Equilibrium" \textit{Economic Journal}, June, 1930, pp. 194-214, "The man who holds that nothing has yet been accomplished (by use of stationary state and static laws) may deserve pity but certainly not respect": p. 194.

\textsuperscript{3}When the shifts are "systematic" and the supply and demand schedules are functions of different variables (such as price with a lag on either the supply or the demand side but not both), then of course the parameters can be determined. Allen, R. G. D., \textit{Mathematical Economics}, Macmillan & Co. Ltd., London, 1957, pp. 12-13.
context we shall first suggest and test hypotheses explaining the determination of long-term tanker rates in the short run, and then analyze the factors determining the long-run level of long-term rates.¹

¹For the reader who is not acquainted with the terms used in the tankship markets, a glossary is included in the appendix.
Chapter II

Expectations and the Behavior of Buyers and Sellers

Before we proceed with the analysis of the objective factors that affect the supply and demand schedules of tankship capacity, we shall briefly present a hypothesis and the consequent theoretical formulation that we shall test in later chapters. This hypothesis concerns the behavior of buyers and sellers and the influences of this behavior on the shape of the supply and demand schedules. Simply stated, our hypothesis adumbrates elasticities of expectations of value greater than one, and also a certain degree of asymmetry between the behavior of buyers and sellers. Such an asymmetry of behavior as we will show later, however, is neither a necessary nor a sufficient condition for stability in the tankship markets. We hope to provide convincing evidence that although the characteristics of these markets create wide price fluctuations, yet such fluctuations are confined within definable bounds even under the impact of price-elastic expectations.

It has long been assumed that elastic expectations (expectations that the percentage changes in future price levels will be in excess of percentage changes in present prices) generate explosive price patterns and result in market instabilities. Hicks in his Value and Capital\(^1\) states that when elasticities of expectations become all equal to one "there is no longer any opportunity for substitutions over time." Further he adds:

\(^1\)Hicks, op. cit., p. 251.
"a system with elasticities of expectations greater than unity, and constant rate of interest, is definitely unstable."\(^1\) Baumol also makes similar observations in his *Economic Dynamics.*\(^2\) The reasoning behind these statements is as follows:

With constant interest rates and elasticities of expectations all equal to one, people will not alter their pattern of preference between present and future transactions, because prices increase or decrease in the same proportion and in real terms remain unchanged. In other words, the tangents to the relevant points on the indifference curves will keep the slope that they had before the price change. With elasticities of expectation greater than unity, where future normal prices are expected to rise or fall permanently and proportionately more than the present price changes, an increase in prices will induce the buyers to accelerate expenditures and the sellers to accelerate input but postpone output. This will further increase prices, increase demand and so on *ad infinitum.* The opposite will occur in the case of a price decrease with elasticities of expectations greater than one.

The assumption of constant interest rate may be somewhat unrealistic under the influence of elastic expectations, and the only case that it does not affect interperiod substitutions is that of unitary elasticity. In effect the latter happens to be also the case where even a variable interest rate may not affect any product markets, with the possible exception of the

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\(^1\) Hicks, *op. cit.*, p. 255.

money (or securities) market itself for reasons independent from the rest. That is to say although people may choose to borrow or lend money in order to take advantage of the expected change in the interest rate, yet they may in no way change their stock of goods, if their expectations in the non-monetary markets are unit elastic. Under all other conditions (whenever expectations are not unit elastic) the cost of carrying inventory will be an important factor that will undoubtedly influence purchasing plans.

If we now consider the money market as a part of the total system under symmetry in expectations, we will find it necessary to make certain changes before the theory is applicable. Firstly we will have to redefine unitary elasticity so as to take into account the impact of the cost of capital and then derive a coefficient of expectations for interest rates in order to

1 In this case the people who borrow will have to evaluate, over the relevant investment horizons, the expected cost of keeping money idle versus the expected gain due to a later increase in interest rates. Those who lend must consider the expected gain that they will realize if they lend now versus the expected loss of utility that they will suffer by being deprived of the use of their money earlier.

2 If money is borrowed ahead of the point of need in order to take advantage of lower interest rates, then the stocks of other goods may be affected even under unit-elastic expectations if the expected future normal price of these goods before the change in present prices occurs, is higher than the present price. It all depends upon these price differences versus the value attached to liquidity, that is to say it depends upon the conditions that determine whether the opportunity cost of idle funds over the relevant period is zero or positive. Let us notice again, however, that this situation will occur only in cases where people are indifferent between present versus future transactions in all markets but that of money.

3 It must be pointed out here that "small changes" in interest rates may not affect the relevant cost of capital of firms and individuals. Consequently the investment behavior of individuals under these conditions will be the same as in the case of constant interest rates.
cover the case of people who are either short or long in liquid funds.\textsuperscript{1} The amount of funds held by people can be either assumed to have been determined by choice or by initial endowments.

In addition to the assumption of symmetry of expectations among buyers and sellers Hicks' formulations relating to elastic expectations further assume monotonicity in the functions relating present to future price changes, constant marginal utility of money, and absence of aversion to risk. Without these assumptions interperiod substitutions may cease and thus curb explosive price patterns.

After staying dormant for quite a few years, interest in elasticities of expectations and dynamic stability has been aroused by a series of publications.

Entovchen and Arrow in an article that appeared in \textit{Econometrica}\textsuperscript{2} have shown that expectations need not necessarily create instabilities in an otherwise stable system. Their conclusions which are an extension of Metzler's theorem\textsuperscript{3} to the case of nonstatic expectations, relate stability to "extrapolative expectations" and to the reaction of the system to a change in expected future prices. In their words "... a necessary and sufficient condition for the stability of the system with any expectation is that $1/K_i > b_1\forall_i$ for all markets...(i.e.) the coefficient of

\textsuperscript{1}The importance of a relevant coefficient of expectations for interest rates may be seen in the following simple illustration. If the prices for all goods go up by 10 per cent in a year, then the holdings in these goods of each person in monetary terms will increase by 10 per cent. This will not be so, however, in the case of the current monetary value of liquid funds if the interest rates increase by 10 per cent.


insensitivity of prices to excess demand be greater than the destabilizing force of the extrapolative expectations."\(^1\) An extension of the Enthoven-Arrow theorem to other classes of matrices appeared in Arrow and McManus "A Note on Dynamic Stability."\(^2\) Finally Arrow and Nerlove\(^3\) by assuming "adaptive" rather than "extrapolative" expectations have shown that the degree of inertia of the system to a change in expected future prices does not affect the stability of a dynamic system which is stable under static expectations.

The conclusions reached in the above mentioned articles which are not insignificant, appear to have been somewhat prejudiced nonetheless, by the assumptions of the extrapolative and adaptive nature of expectations. As Mills\(^4\) points out in the case of adaptive expectations, since prices are assumed to follow a smoothed out path based on actual prices, which in the long run are assumed to converge, expectations will converge also.

With the above brief discussion on the impact of elastic price expectations on the stability of general market equilibria, we will now examine the theoretical consequences of an assumption that dynamic forces operate in tankship building and tankship transportation markets.\(^5\) Since we will

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\(^1\) Enthoven and Arrow, \textit{op. cit.}, p. 290.


\(^5\) This topic was also explored in 1939 by Jan Tinbergen, see \textit{Selected Papers} L. H. Klaassen et. al. Editors, North Holland Publishing Company, Amsterdam, The Netherlands 1959, pp. 1-14 and Tjalling C. Koopmans in his \textit{Tanker Freight Rates and Tankship Building}, Haarlem 1939.
be interested in partial equilibria, in some ways our task will be easier than that of investigators dealing with conditions relating to general equilibrium analysis. Budgetary constraints and shifts in wealth that may not operate in the general case will definitely curb interperiod substitutions in partial analysis. Yet in other ways the task of the empirical investigator is more complicated by the fact that any theoretical model that he develops must be realistic enough and devoid of excessively simplifying assumptions so that it may withstand the empirical test for validity.

The nature and dynamics of the fluctuations in the tankship building and tankship transportation markets are much more complicated than those described by the classical cobweb theorem or the cattle and hog cycles. Ships are not as perishable as cattle, hogs or wheat, so the production cycle does not fully determine the duration of the price cycle.\footnote{Within the life span of tankships which is about twenty years we may observe several price cycles even for reasons purely endogenous to the supply side of the market. It all depends upon the time distribution and magnitude of the various supply quantities as these enter and are withdrawn from the market. This topic will be expounded later.} In fact as we will show later the interrelationship between tankship services and tankship building is such that the price upswing in the tankship services market may be (and usually is) reversed before the output that was initiated by dynamic anticipations reaches the final market. Furthermore it appears that in the tankship markets we are presented with a strange situation where the expectations of the operatives will often appear \textit{ex post facto} to be rational\footnote{Price expectations are defined as rational if expected prices are an unbiased estimator of actual prices.} while the \textit{behavior} of these operatives is

\textit{...}
irrational.\(^1\) In other words by means of their behavior, which appears to be irrational, those who operate in the tankship markets influence the actual price to the extent that it confirms their expectations. Another peculiarity of the tankship markets that is worth mentioning relates to the organizational structure of the petroleum industry. Tankship transportation, the rates of which are determined under conditions that approximate perfect competition,\(^2\) is an input to a good whose final price seems to bear little if any relationship to its marginal cost. Consequently wide rate fluctuations are to be expected, especially if one considers also the loss of goodwill or penalty of default of contractual commitments.

Ignoring for the time being the nature of expectations, to the extent that in the final analysis we are interested in determining the impact of price changes on the quantity demanded, at any moment of time, the Slutsky-Hicks formulation for the consumer equilibrium presents a very convenient avenue of exploration.\(^3\) Although this formulation was originally developed in order to analyze the static income effect and the income-compensated substitution effect of a price change on the

\(^1\)For example in late 1956 during the Suez Canal crisis we find instances of charterers who signed agreements for delivery of vessels in 1962 to commence a rental engagement of ten years' duration. And this at a time when shipyards were accepting orders for a three-year delivery. The rental rates were high enough to allow banks to lend up to 90 per cent of the cost of the vessels that were to be built for these commitments, and be sure of repayment of such loans out of the net rental in five years. So one wonders as to how much information is wasted in practice.

\(^2\)See the chapter entitled "Characteristics of the Tankship Transportation Market."

\(^3\)This formulation is otherwise known as the "fundamental equation of value" or the Allen-Hicks formulation. See Hicks op. cit., Mathematical Appendix to Chapters II and III pp. 307-314. Also R. G. D. Allen, Mathematical Economics Macmillan and Co. Ltd., London 1957, pp. 658-664.
quantity demanded at a moment of a time, for the purpose of maximizing utility for a single period, yet as we show in the appendix it is also applicable in the case of interperiod substitutions. 1

In effect this implies that the various amounts of commodities, which an individual plans to purchase, are substitutes or complements not only at that moment of time but also over time. In the absence of price-elastic expectations, therefore, an increase in the price of a commodity will decrease the consumption of the commodity and increase that of its substitutes both currently and in the future. If now expectations are that a price increase will occur in the future, then this will lead to an increase in current consumption of the commodity if it is a substitute for future consumption of that very same commodity. On the other hand it will lead to a decrease in current consumption if there is complementarity among the amounts of the commodity consumed over time.

There is another comment that we must make concerning the Slutsky-Hicks formulation. The theory underlying the latter was aimed at describing consumer or household behavior. Does this therefore imply that it is inapplicable in the case of intermediate goods or goods whose demand is derived? In our opinion the answer is no because even consumer goods may be considered as intermediate to final utility or satisfaction and consequently facing derived demand. There are no impairing differences between marginal rates of substitution which are based on industrial marginal physical productivities and consumer marginal utilities, nor any

1 See "Interperiod Maximization of Profit or Utility" at the end of this chapter. This result was also pointed out by Jacob L. Mosac in General Equilibrium Theory in International Trade, The Principia Press, Inc., Bloomington, Indiana, 1944, p. 122.
weakening compromises of theory if we assume that industrial budget con-
straints operate in the same way as do those of the individual consumer. 
Consequently, although the Slutsky-Hicks formulation was originally 
developed to apply in the static case of consumer equilibrium, we find 
that it also applies in the case of interperiod maximization of utility, 
as well as in the case of nonhouseholds.

Our investigation of the impact of price-elastic expectations on partial 
market stability over time will still be in terms of short-run analysis. 
In doing this no restrictive assumptions will be made as to any specific 
pattern of expectations, extrapolative or adaptive. It will be shown that 
such price movements are bounded and that at least one-way stable equilibria 
can occur in markets affected by price-elastic expectations. Such expecta-
tions, we will later point out will cause in the long run cyclical price 
patterns in the tankship markets without the necessity of cyclical demand.

Whenever a market is at a short-run equilibrium we shall assume that 
there exists a price level $P_f$ which the operatives in the particular 
market expect to prevail in the future. Changes in this expected future 
price level are assumed to be a function of the changes in the present 
price. In this respect this formulation borrows from Arrow-Nerlove\(^1\) 
rather than Enthoven-Arrow,\(^2\) in that we are using an "expected normal 
price" but in our case this expected normal price is taken before any 
changes in the present price $P$ occur. As long as the market is at an


equilibrium point, only static expectations are assumed to prevail and the latter determine the expected future price level. There is no reason, however, why it must be concluded that static expectations necessarily imply a future price level equal to current prices. For example technological economies of scale both internal as well as external may still operate on the long-run supply schedules in a way that allows a determination of the future price level under static conditions. We, therefore, assume that the level is affected by factors endogenous as well as exogenous to the particular market, but that the future price level under static conditions can be derived from objective data before any changes in present prices occur.

It seems logical to assume that there exist a price range around each stable short-run equilibrium within which prices may move without setting into motion dynamic expectations. A price movement beyond this range, however, which we call the "price range of strict static relevance" will cause dynamic interperiod substitutions. The magnitude of this range is determined, we believe, by the characteristics of the particular market which cannot be satisfactorily included in a general formulation, but which factors nonetheless do not affect the general conclusions that

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1 If prices move in discontinuous jumps the assumption of a price range of static relevance will be workable as well as realistic. Only in cases of a continuous monotonic price "drift" it may fail, but here again the drift may be due to shifts in the short-run equilibrium point rather than be the result of disequilibrating price movements.
can be drawn from this discussion. Although this assumption is rather unnecessary and may appear to be somewhat gratuitous at this stage, it is introduced nonetheless in the hope that it will help the reader follow our subsequent discussion.

In considering the impact of price-elastic expectations on the equilibrium of a single market, we shall assume that cross price affects are negligible and that the only substitutions that can occur are of interperiod nature. The latter assumption may seem to be restrictive but in actuality it is not, for if we can prove that short-run stability at various points of time under such conditions is possible, then for sure this will be true if we assume that other prices and quantities can move freely in order to stabilize the markets unless, of course, complementarities exist. In our case, however, the goods offered over the various time periods are substitutes and not complements. Furthermore, and this as a justification for the choice of dealing with short-run rather than long-run equilibria, if we can show that no short-run price at any point of time is unbounded then we can conclude that long-run prices are not explosive even though not necessarily stable. In order to see the realism

1The characteristics that we have in mind include: the type of end use of the product (how urgent are the needs that it satisfies); if an input factor is concerned, the imputed profit to this input; the range over which the supply schedule is elastic (that is to say the range beyond which even the most inefficient suppliers not only cover their full cost but also realize satisfactory profits). In general we can say in a vague way that this range is bounded by limits beyond which prices cannot be explained by "normal" and objective data.

2In the case of tankers which is our main concern, while it is true that chartering of tankship services and tankship building are alternatives over the long run (time horizon of at least two years), yet these are not substitutes in the short run. Consequently the assumptions of negligible cross price effects and no substitutions other than of interperiod nature are quite realistic.
of arguments on the production plan one may take the markets to be intermediate to a final product, the later being either physical product or utility.

For the convenience of the reader the special notation that will be used in the subsequent discussion is summarized here:

\[ E = \text{the price of elasticity of expectations defined as} \]
\[ \left( \frac{\partial P_f}{\partial P} \right) \left( \frac{P}{P_f} \right) \]

Where \( P_f \) stands for the future price level and \( P \) for the present price. The lower case subscripts "b" and "s" will be used to denote the price elasticity of expectations of buyers and sellers respectively. The range of \( E \) is assumed to be finite.

\[ E_D = \text{the price elasticity of demand defined as} \]
\[ \left( \frac{\partial Q}{\partial P} \right) \left( \frac{P}{Q} \right) \]

\[ E_{D,M} = \text{the income elasticity of demand} \]

\[ E_{D,P_f} = \text{the elasticity of demand with respect to future price} \]

\[ R^S = \text{the price region of strict static relevance, namely the set of all prices around the static equilibrium such that dynamic price-elastic expectations are absent.} \]

Let us assume that the demand for a non-inferior product \( X \) at any moment of time may be represented by

\[ Q = K + f(P_f) \]

where \( K \) is a constant representing the demand under static expectations, at which time \( f(P_f) = 0 \). Under dynamic expectations \( f(P_f) \neq 0 \) and \( P_f = g(P) \).
We will now proceed to determine the impact of interperiod substitutions on the quantity demanded of a commodity at any moment of time.

From equation (16) of the Appendix and for \( s = 0 \), we have:

\[
\left( \frac{\partial Q}{\partial P} \right)_T = \text{constant}
\]

where the first term on the right-hand side represents the income effect of a price change and the second term the income-compensated substitution effect.

If \( E_b < 1 \) then \( \left( \frac{\partial Q}{\partial P} \right)_T \) = constant \( < 0 \); but \( \frac{\partial Q}{\partial M} > 0 \) if \( X \) is not an inferior good, therefore \( \frac{\partial Q}{\partial P} < 0 \). The latter implies that whenever the price of \( X \) goes up to the extent that future prices are expected to increase proportionately less, the quantity demanded goes down thus creating excess supply which restores equilibrium. If the price goes down, because again future prices are expected to decrease proportionately less, the quantity demanded increases, creating excess demand which restores the market to its previous equilibrium position. In the case where \( E_b = 1 \) (expectations of unitary elasticity) and there exists no interference from the purely monetary markets, there will be no interperiod substitutions, that is to say \( \left( \frac{\partial Q}{\partial P} \right)_T = \text{const.} = 0 \), but the total effect may be negative because of budgetary considerations. That is to say the income effect \( -Q \left( \frac{\partial Q}{\partial M} \right) \) is negative and will thus tend to restore equilibrium.

If now \( E_b > 1 \) then the income-compensated substitution term \( \left( \frac{\partial Q}{\partial P} \right)_T = \text{const.} \) is positive because:

\[
(2) \quad \left( \frac{\partial Q}{\partial P} \right)_T = \text{const.} = \left( \frac{\partial Q}{\partial P_f} \right) \left( \frac{\partial P_f}{\partial P} \right)
\]

\[
(3) \quad = E_b E_{D,F} P/Q
\]
where $E_b$ stands for the elasticity of expectations of buyers and $E_{D,P_f}$ for the elasticity of demand (income-compensated) with respect to future prices. The value of $E_{D,P_f}$ is positive whenever $E_b > 1$; consequently

$$\left( \frac{\partial Q}{\partial P} \right)_{\Pi = \text{const.}} > 0,$$

indicating that the income-compensated substitution effect will cause an increase in the quantity demanded of a good, if present prices increase and cause a decrease if prices decrease, because of price-elastic expectations.

The income effect $-Q\left( \frac{\partial Q}{\partial M} \right)$, however, is negative because $\frac{\partial Q}{\partial M} > 0$ since we are dealing with non-inferior goods.

Equation (1) therefore becomes:

$$(4) \quad \frac{\partial Q}{\partial P} = E_b E_{D,P_f} Q/P - Q \left( \frac{\partial Q}{\partial M} \right)$$

If we multiply both sides of equation (4) by $P/Q$ and simplify we obtain:

$$(5) \quad E_D = E_b E_{D,P_f} - P E_{D,M} Q/M$$

where $E_D$ is the price elasticity of demand, and $E_{D,M} = (\frac{\partial Q}{\partial M})(M/Q)$

or the income elasticity of demand.

It can be seen from the Appendix that $M$, the total money available, can be safely taken to be bounded, since we are dealing with partial equilibria and do not assume identity in the expectations of each and every persons with respect to each and every market at any moment of time. Furthermore, the interest rate and budgetary constraints that definitely operate in any particular market at any moment of time set an upper bound
to the available monetary resources. A much stronger statement can be made in the case of non-households, (industrial operations) where each decision-making subentity of the firm operates under budgetary constraints. As a result both $E_{D,P_f}$ and $E_{D,M}$ are mathematically well behaved, are positive and finite. The elasticity of expectations of buyers $E_b$ is assumed to be positive and also finite. Consequently by the "Archimedean property" there exists a $P^*$ for which in equation (5)

\[(6) \quad P^*E_{D,M}Q/M > E_{D,E_{D,P_f}}\]

Inequality (6) implies that for all $P > P^*$, $E_D < 0$ even though $E_b > 1$; therefore before prices reach infinity the demand schedule will assume a negative slope and $Q$ will approach zero uniformly. This sets an upper bound for prices.

\(^1\)Under identity in expectations with respect to every market at any moment of time and symmetry of expectations between buyers and sellers, we may be presented with a rather academic case where

\[
M = \sum_{t=1}^{N} P_t Q_t e^{-r_t}
\]

may not be bounded. For example let us assume that the buyers of inputs $Q_i$, for $i = 1$ to $m$, derive their monetary resources from the ownership of products $Q_j$ ($j = 1$ to $n$). If elastic expectations operate in both the $Q_i$ and $Q_j$ markets for some $i$ and $j$, then $M$ may not be bounded if the net result is for $Q_j$ prices to increase by a factor $e^{r't}$ where $r'$ is greater than $r$, and for all practical purposes close to infinity. We said that this case is rather academic because the wealth of such individuals will be on paper until they enter the market to realize them. Otherwise they will have no cash budget at all, and consequently carry very limited if any transactions. If on the other hand they do enter the market then they will sell at a finite price and so establish a finite budget. We must further add, however, that the probability of such an occurrence under partial analysis and absence of identity in expectations is infinitesimal.

\(^2\)The "Archimedean property" states that for any two real number $a > 0$ and $b > 0$, there exists an integer for which $na > b$. For proof see Birkoff & Maclane, A Survey of Modern Algebra, The Macmillan Company, New York 1949, p. 69.
Below the initial equilibrium point, a disturbance accompanied by elastic expectation will send prices to zero unless the magnitude of \( E_{D,M} \) is such that it will make \( E_{D} \) negative.

Intuitively it is obvious that even with price-elastic expectations any price movements must be bounded so the theoretical conclusions that we reached should not come as a complete surprise. Undoubtedly, there must be a prohibitive price beyond which there will be no transactions. Similarly, since we are dealing with non-inferior goods it is not logical to expect \textit{ad infinitum} negative purchases (sales by users) at negative prices, even if we allow for inventory carrying charges. As we will show later in the tankship markets we often observe negative purchases at negative prices but the latter are still bounded by the expected out-of-pocket cost involved in keeping vessels idle.

On the basis of the above relationships we can conclude that only if the resources are unlimited (actually infinite with zero interest) or alternatively (i) the income elasticity of demand is infinitesimal (the reciprocal of infinity) and (ii) the purchase of a given commodity utilizes "a very small portion" (reciprocal of infinity) of a given budget will price elastic expectations cause indeterminate or explosive price patterns, in any one market. Assumptions such as these, however, are quite unrealistic, especially if the commodity is an intermediate good. In the latter case the budget is a function of the demand of the final product and the highest purchase price will be that which will absorb all expected profit and result in a loss equal to the penalty of default of contractual obligations (or loss of "goodwill").
In relationship (6) the quantities $M$, $E_{D,M}$ and $E_{D,P_f}$ that is to say the income, income elasticity of demand and elasticity of demand with respect to future prices are all properly discounted whenever necessary, by the relevant cost of capital and for the appropriate time periods because we are dealing with interperiod substitutions.

Turning now to the shape of the demand schedule, we find that elastic expectations will create four definite price regions and depending on the magnitude of $E_{D,M}$, possibly a fifth below the initial static equilibrium. These regions are:

1. $R_1 = \{P_i : P_i \in R^S\}$ for $0 \leq E_b \leq 1$ and where by definition the total effect of a price change $\partial Q/\partial P$ is negative.\(^1\) As the reader may remember this is the region we previously called the price range of strict static relevance, because we felt that it is only logical to assume that dynamic (price-elastic) expectations are not excited unless the market receives a jolt. Small price movements around an equilibrium point are to be expected.

In the absence of the above assumption, the region $R^S$ will shrink to a point and result in an unstable equilibrium. In such a case, even the slightest movement away from the equilibrium point on either side will cause wild fluctuations.

\(^1\)The special notation used here, for example $R_1 = \{P_i : P_i \in R^S\}$, should be interpreted as follows: The region $R_1$ equals the set of all prices $P_i$ such that $P_i$ is included in region $R^S$.\(^1\)
(ii) \( R_2 = P_{ii} : P^* > P_{ii} > P_i \) for \( E_b > 1 \) and total effect 
\( \frac{\partial Q}{\partial P} > 0 \)

(iii) \( R_3 = P_{iii} : P_{iii} > P^* \) for \( E_b > 1 \) and total effect 
\( \frac{\partial Q}{\partial P} < 0 \)

(iv) \( R_4 = P_{iv} : P_i > P_{iv} > P_L \) for \( E_b > 1 \) and total effect 
\( \frac{\partial Q}{\partial P} \geq 0 \) (where \( P_L \), the low price, equals zero if the fifth region \( R_5 \) does not exist.) and finally depending on the value of \( E_{D,M} \)

(v) \( R_5 = P_v : P_v \leq P_L \) for \( E_b > 1 \) and total effect 
\( \frac{\partial Q}{\partial P} < 0 \)

The shape of such a schedule appears in Figure 1.\(^2\) The range and slope of the various demand segments have not been chosen to be representative

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\(^1\)Actually in order that region \( R_5 \) be empirically observable, the effect of \( E_{D,M} \) is necessary but not sufficient. We must also have a relevant supply schedule in that region, which implies that the costs of exit from and re-entry into the market are such that they will generate offers from suppliers at prices in region \( R_5 \).

\(^2\)This demand schedule may be considered by some as a cutout from a three-dimensional surface that is to say the regions outside \( R^S \) may be thought of as the loci of temporary intertemporal equilibria. We do not believe so, but even if it were so still as we would shortly argue it would make no difference.
of anything specific so no quantitative importance should be attached to this particular choice. The reader may also notice that in Figure 1, the quantity Q is a function of present price P, although previously in the process of developing our theoretical formulations we assumed

\[ Q = K + f(P_f) \]

that is to say, we assumed that Q is a function of \( P_f \).

The reasons for the change are mainly three.

1. In dealing with interperiod substitutions caused by expectations, we are concerned with the impact of these expectations on present quantity demanded. But these expectations are initiated by changes in present prices. Consequently, it is not the particular expected level of future prices that is important, but the relative changes to that level. And to repeat again, the changes \( \Delta P_f \) are in our analysis a function of \( \Delta P \), and they are the only important consequence of a present price change.

2. Given any expected future price before any change in present prices, with the aid of a coefficient of expectations directly relating present to future changes, one will be able to arrive at the level of future prices. This complication is, however, unnecessary for our exposition. There is no way of obtaining objective observations of future prices. Consequently, we must be content in dealing with the manifestation of their existence, and measuring with the aid of substitutes.

3. If we wish to derive relationships which can be used for decision making, it is not enough for the related entities to be observable. They must be observable soon enough to allow for forecasts and analysis, and thus enable changes in behavior if necessary. As a result, the prognostic qualities of approximate relationships are often much more valuable than the damages caused by functional impurities.
To summarize then, in Figure 1 our choice of $Q = f(P)$ rather than $Q = f(P_f)$ was dictated by empirical realities. Such a compromise, which as we have argued is not really damaging, will aid us in our subsequent analysis of the tankship markets. We will show later that there exists a very close similarity between the theoretical schedule of Figure 1 and the empirical demand schedules of tankships and tankship transportation.

As we have already mentioned, implicit in Hick's formulation is the notion of complete symmetry in the expectations of buyers and sellers in all markets. With the knowledge of the shape of our hypothetical demand schedule (which is shown in Figure 1) we can easily prove that partial equilibria outside $R^s$ are possible, even under symmetry which implies that $E_s > 1$ whenever $E_b > 1$. It is obvious that the necessary and sufficient conditions for an equilibrium above $R^s$ rest with the relationship between the slopes (magnitude) of the demand and supply schedules in regions $R_2$ and $R_3$. By assumption (symmetry in expectations) the supply schedule in these regions is of negative slope.\(^1\) Such an equilibrium point, whenever it exists, must be in region $R_3$ and will only be stable from below unless we assume reversibility in the demand and supply schedules. Region $R_2$ is a price range of instability, because for the whole range the supply schedule will be of negative slope while the slope of the demand schedule will be positive.

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\(^1\)In the case of consumer goods because the income effect for suppliers is positive rather than negative (as in the case of buyers), we may get supply schedules of more pronounced negative slopes in regions $R_2$ and $R_3$. 
Equilibria below $R^S$ can exist depending not only on the relative magnitude of the slopes of the supply and demand schedules but also on the magnitude of $E_{D,M}$. All the prices in region $R_4$ constitute potential unstable equilibria for the same reasons that make $R_2$ a region of instability. The slope of the supply schedule in region $R_4$ is expected to be negative in the case of consumer goods, not only because of the assumed symmetry in price-elastic expectations between buyers and sellers, but also because of the impact of the budget (income) effect on the suppliers. As their income goes down because of the drop in prices of the goods they possess, they will tend to supply more and consume less of the affected commodities. There will be a price, however, at which it will be catastrophic for them to produce and as a result they will withdraw from the market. This occurrence will undoubtedly precipitate a change in expectations, from elastic to inelastic, and further accentuate the positive slope of the supply schedule. It is for this reason that in region $R_5$, if it exists, we may find stable equilibria but these points are only stable from above unless again reversibility in the schedules is assumed.

Figure 2 depicts the shape of a supply schedule under the impact of price-elastic expectations. Its general outlines are similar to those of

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1 This of course assumes that a relevant supply schedule exists in this whole region. Because only if the sellers refusal price is less than $P_1$ will the supply and demand schedules intersect in region $R_4$ for an unstable equilibrium. If the refusal and re-entry prices of the suppliers happen to be included in $R_4$, then $R_5$ does not exist and at least one-way stable equilibria may be observed in region $R_4$. 

Demand Schedule Showing the Impact of Price-Elastic Expectations Outside $R^S$
Theoretical Supply Schedule Affected by Price-Elastic Expectations outside $R_1$
the demand schedule shown in Figure 1. Because of the assumption of symmetry in expectations between buyers and sellers, however, the two schedules are "out of face." We must stress that only in the case where suppliers can adjust instantaneously do we expect to observe such a schedule.

Finally another comment on the demand schedule as shown in Figure 1. Whether the regions outside $R^S$ are caused by purely interperiod substitutions generated by elastic price expectations as we have assumed, or else generated by shifts in an otherwise non-existent static demand schedule and which shifts have their origin in price expectations, it is actually immaterial. In other words it makes no difference if the regions outside $R^S$ are the loci of shifts in an assumed static demand schedule of the traditional shape, as long as such a traditional schedule never exists in these regions. We believe, however, on the basis of empirical observation, that this is not the case. Under the circumstances described, the schedule as shown in Figure 1 is the only relevant schedule in our estimation, and if shifts do occur, because of the elastic price expectations, the whole schedule with all of its regions shifts. These same arguments can be made for the supply schedule.

**Asymmetry in Expectations**

If we now assume asymmetry in the behavior of buyers and sellers—or at least manifested asymmetry—we will find that buyer elastic expectations may not be allowed to bloom fully. The time period over which such elastic expectations will operate will not extend beyond the production cycle, or the time it takes to produce a sufficient shift in the supply schedule and cause a price precipitation.
Figure 3 presents one type of asymmetrical pattern of expectations and non-uniformity of functions. It shows that as the demand increases eventually the expectations of the sellers become elastic and those of the buyers inelastic, thus bringing forth the excess supply which will eventually satisfy the increased demand and, in the absence of any lag between cause and effect, guarantee a return to stability. The pattern of expectations assumed in Figure 3 implies the existence of demand schedules with positive slope, at least for certain price ranges. The slope of the supply schedule, however, will not in general change the sign of its traditional slope but will become more elastic.

In case expectations are compounded and alternate between elastic and inelastic, we may get a pattern of interweaving supply and demand schedules. It all depends upon the magnitude of the difference between the coefficients of expectations of buyers and sellers, whether or not such a "braid" effect is obtained. If it does materialize, then stable equilibria will alternate with unstable equilibria. In case interweaving is not achieved, then the presence of dynamic expectations will not be destabilizing, because the asymmetry in the behavior of sellers will generate the necessary excess supply (unless of course the supply and demand schedules happen to coincide). If instability is averted, then the pattern of expectations may not leave any observable empirical trace.

It is not unreasonable to assume that expectations alternate between elasticity and inelasticity, if the market stays long enough at an

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1 No particular significance should be attached to the numerical value of the slopes of these two schedules of expectations.
FIGURE 3

Expectations Schedules
equilibrium point, before it goes into a spin again. And this because the "memory" of those operating in the market may not last long enough to recall how the market came to rest at that particular equilibrium point. Consequently, any equilibrium point is taken to be the normal static equilibrium and a move away from it excites price-elastic expectations.

Finally we must note that on the basis of empirical observations it may be very difficult, if not impossible, to distinguish between the case of asymmetric expectations-interwoven pattern and symmetric expectations, unless more than one cycle in expectations materialize.

**Supply and Demand Interactions Under Elastic Expectations**

As a means of studying the impact of expectations on market equilibria, especially whenever shifts in the schedules are also present, nine schedules of supply and demand are shown in Figure 4. Schedule 1 shows the traditional normal long-run demand schedule, which assumes "all other things equal" with the exception of the price change of the particular commodity. To the extent that dynamic expectations are assumed to be operating and be a function of present price changes, a static demand schedule as shown in Schedule I with zero elasticity of expectations is very improbable.\(^1\)

Any real price movement will generate dynamic expectations which, in turn, will increase the quantity demanded in the short run rather than decrease it, because of shifts in the short-run investment possibility schedules at the various points of time.

\(^1\)If it is assumed that the elasticities of expectation are zero then we revert to the case of static stability. See Hicks, *op. cit.*, pp. 245-282.
Schedules II through IX present demand schedules exhibiting the impact of price-elastic expectations of the type that we have assumed, and symmetric behavior between buyers and sellers. The end points of these schedules take the shape shown because of the income effects of price changes, and the shape of the expectations schedule. As for the supply schedules, to the extent that the impact of the dynamic expectations cannot be felt instantaneously, because of the length of the reaction and/or production cycle, they could be of the traditional shape. Consequently, we have chosen to show the supply and demand interactions under both sets of assumptions. Figure 4 will use supply schedules of the traditional shape because of slow reaction of the supplies and Figure 5 will show the consequences of the assumption that the suppliers react without excessive time delays. It must be noted again at this time that what we have said concerning the demand schedules has nothing to do with dynamic shifts in demand or shifts over time in the quantity demanded due to reasons other than expectations. Our analysis up to this point is still in terms of statics but with an elasticity of expectations not necessarily zero. That is to say, some dynamic factors work in a certain manner to cause even the applicable short-run demand schedule assume, as of a given moment of time, a shape different from the traditional.

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1To be exact, these schedules are not based on the elasticity of expectations as defined by Hicks, op. cit., p. 205, but on coefficients of expectations as used in smoothing functions. The reason is that the notion of the elasticity of expectations "does not tell us what the expected price is but merely how it changes when present price changes." Baumol, op. cit., p. 210. However, such a distinction does not in any way affect our exposition.
A. Delayed Reaction of Suppliers

Schedule II of Figure 4 shows a market at equilibrium, even though the supply and demand schedules are under the impact of price-elastic expectations. Because of the assumptions underlying Figure 4, that the reaction of the suppliers is not instantaneous, the impact of expectations on the supply side is limited to a counter-clockwise rotation of the supply schedule.

We notice in Schedule III, that once something happens and causes a shift to the right in the demand schedules\(^1\) (such as the Korean War and the Suez crisis in the case of tankships), a movement away from the temporary equilibrium "a" will occur. Prices will rise, which may condition expectations about further shifts. Depending on the intensity of the shock, the initial rise in price may be confined between "a" and "b" in which case it will tend to gravitate toward "a" before a secondary shift in demand occurs; or it may go beyond "b." In the latter case, because "b" is a stable equilibrium from above but not from below\(^2\), the price may drop all the way toward "a" or stay temporarily at "b," depending on how wide and swift are the adjusting oscillations. The amplitude of these oscillations will depend upon the severity of the original shock and the net effect of

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\(^1\) This implies expectations about shifts in all envisioned schedules in the future not shifts caused by substitutions between years. The same results are obtained if the supply schedules shift to the left (because of retirements of facilities). As we will show later, shifts in the supply schedules are very critical for the operations in the tankship markets and can create cyclical patterns in tankship rates.

\(^2\) Below "b" but above "a" the quantity supplied at each intermediate price is greater than the quantity demanded; hence the price will tend toward "a." But we notice that the same situation exists above "b," which will make "b" a stable equilibrium from above, but not from below.
possible secondary shocks that may oppose each other. More shifts may occur, however, because the initial rise in price may set such shifts in motion. From the second shift on, the relative intensity of the opposing movements will determine the direction of the rate fluctuation. In addition to shifting the demand schedule to the right, the original shock and the rate of change in prices may cause a clockwise rotation of the demand schedules.

A possible sequence of shifts may take the markets through schedules IV to IX. Schedule IV of Figure 4 shows that prices could rest (if sufficient time were allowed to end the oscillations) at either "a" or "c," but not at "b" because "b" is unstable. Schedule V shows that above "b" the price moves "skyward," possibly not only because of the shifts in demand but also because of shifts toward the left in the supply schedules. The latter shifts shown better in Schedules VI and VII may occur if the owners have had time to react to the elasticity of their expectations, or reach the elastic point on their expectations schedule. The next possible shift in demand, therefore, may establish "c" of Schedules VI and VII as the only stable equilibrium.

The market now enters its most critical and precarious stage, and it is ready for a reversal. It cannot stay long at point "c" for one of several reasons.

1. The demand schedule may not be reversible. This will make point "c" a stable equilibrium from below only and not from above. Consequently, any price fluctuation, in such a case, will be destabilizing and will create chaos and panic.

It is very probable that the demand schedules are not reversible, outside the region of strict static relevance. As soon as prices start sliding downward, elastic expectations will dictate withdrawal from the market, which will further accentuate the downfall. Thus the downward movement in prices occurs very swiftly. Similarly, whenever prices go up sufficiently, elastic expectations take over immediately.
2. The withdrawal of the buyers, because of the budget effect, may be taken by the sellers as an indication of reversal in expectations. Such an assumption may generate excess supply, which will cause precipitation in prices.

3. The expectations of buyers may actually change, when they withdraw from the market, and cause shifts to the left in the demand schedules. As a result the market may go through the stages depicted by Schedules III and II.

4. Under the impact of price-elastic expectations, the sellers accelerate input and postpone output whenever prices rise. The acquisition of additional capacity, will undoubtedly shift the supply schedules to the right as shown in Schedule VIII. Consequently, and even if the demand schedules are reversible, the emergence of new capacity will ultimately throw the market into a swift decline. After the oscillations exhaust themselves, the schedules of supply and demand may appear as in Schedule IX, generating overcapacity and short-run equilibrium prices below "normal" full cost.

On the basis of the schedules presented in Figure 4, one can readily see that markets which exhibit the characteristics that we postulated are prone to excess capacity and depression. The movements above the normal short-run equilibrium point occur very swiftly, in both directions. The falls are always of greater magnitude than the rises, because the region of static relevance is bypassed on the downfall. It appears that markets affected by price-elastic expectations laboriously work their way out of overcapacity and depression to reach the region of static relevance for a short respite, in order to plunge again into another adventure. Thus the fate of those operating in these markets is to alternate between a few months of exhilaration and many years of misery.
B. Instantaneous Reaction of Suppliers

If the suppliers react instantaneously to the various manifestations of price changes and the elastic expectations of buyers, then the supply schedule will assume the shape shown in Figure 2. Above the region of strict static relevance the supply schedule will bend backward more sharply as the suppliers adjust to their elastic expectations. Below the static region we now find a price range over which the supply schedule will assume a negative slope, before it reverses itself and proceeds to the origin as prices fall.

The results of supply and demand interactions under these circumstances will not be significantly different from those that we have just considered. The only major difference, as can be seen in Figure 5, will be found below the static region. We notice that because the supply schedule becomes negatively sloped and then reverses itself, two more equilibria are established. The one at point "d" is unstable, but the equilibrium at "e" is stable at least from above.

The fluctuations in a market affected by elastic expectations, symmetric buyer-seller behavior, and instantaneous supplier reaction are undoubtedly more violent and wider. Otherwise, one can readily see by comparing Figures 4 and 5, that the overall market behavior in both cases is similar.

C. Supply and Demand Interactions with Asymmetry in Behavior

Finally let us examine the consequences of an assumed asymmetry in the behavior of buyers and sellers. If the sellers do not or cannot react instantaneously, then this case is similar to the one we examined under A. The analysis made and conclusions reached then are still valid. The only difference is that the inelastic expectations of the suppliers will cause
a clock-wise rather than counter-clockwise rotation of the supply schedule, and may not cause much surplus capacity. Consequently, although the fluctuations will not be eliminated, yet the duration of the price cycles may be shortened.

If the suppliers react without excessive delays their stabilizing influence is even more pronounced. Whether or not such a market can avoid completely the erratic fluctuations inherent in the schedules of Figure 4 no one can tell on an a priori basis. It all depends upon the magnitude of the coefficients of expectations of buyers and sellers, and the impact of such on the quantities supplied and demanded at the various prices.

Of the two assumptions governing the speed of supplier reactions, (instantaneous versus lagged) the most realistic is the one which assumes delayed reaction. There is usually a "lead time" between input and output, and if fixed capacity (capital equipment) must be acquired, then the delays are further increased. As a result we observe that whether or-not behavior is symmetric or asymmetric, the results in general are the same, that is to say, elastic expectations generate wide price fluctuation. These prices are bounded from both above and below and some of the equilibria are stable at least "one way." However, as we have already noted, even the stable equilibria are prone to be temporary under the impact of price-elastic expectations.

The above statements, however, raise a number of questions concerning the quantitative attributes of the turning points and the ranges of the supply and demand schedules. Taking first the demand schedule, we believe that the range of its region of strict static relevance, $R^S$, is determined
by the normal long-run supply schedule at any moment of time. The cost functions of the suppliers are more or less known, consequently costs, and reasonable prices based on such costs, are expected to play a major role in defining the range within which such strict static influences will reign.¹

Once prices move beyond this range, however, and each buyer cannot by himself account for this move on the basis of objective data available to him, he automatically assumes that dynamic factors are operating either on the investment possibility schedules or on the production functions. Being in a completely unstructured situation, he assumes that others know what he does not, his expectations become elastic, and subjective elements rather than "reasonable prices based on costs" influence his behavior. This will continue up to the point where new objective evidence enters to force him reconsider his behavior and awake to face reality. The new evidence under falling prices is in the form of complete withdrawal of the sellers from the market--when they cannot cover their short-run variable costs less any costs necessary for reactivation of their facilities--and under rising prices, complete elimination of all the profit imputed to the product.

For intermediate products, under rising prices, the turning point occurs at the price which eliminates any profit or utility out of the final product. In fact the input price may go beyond the point of such profit elimination from the final product, because of the imputation of any loss of goodwill due to stockouts of the final product. Consequently the greater the profit

¹In the tankship service markets in particular, costs are known to the buyers (the oil companies) because the latter operate vessels also. Furthermore the "firm," as we will later observe, is under normal operating conditions, quite simple (the vessel) and consequently its technology can be easily duplicated.
margins and/or loss of goodwill associated with a final product, the greater the range of the demand schedule over which elastic expectations will prevail to create a positive slope.

Turning now our attention to the supply schedule, we believe that although it is established under expectations symmetrical with those operating on the demand schedule, yet it seems logical to assume that such symmetry is only adopted by the sellers as the latter observe the behavior of the buyers. In other words, the suppliers being closer to objective data take their cue from the manifested behavior of the buyers. Consequently the real expectations schedules that influence the behavior of the buyers and sellers may not be exactly symmetrical or qualitatively identical. First of all the reactions of the sellers may be lagging a little behind those of the buyers, but more important than that, the final turning points of the demand schedule may be taken by the sellers as implying change in expectations. As we have already seen, the income (budget) effects of price changes will cause the turning points, and as a result the demand schedule will assume negative slopes although expectations are still elastic. So even though there is a manifested symmetry, there may be a certain degree of asymmetry in the real expectations schedules. In either case, however, as we have repeatedly stressed and shown during our analysis, the results are the same.

Now what are the intuitive justifications behind such assumed manifested symmetry in the expectations schedules of buyers and sellers?

1. All the reasons that justify symmetry in expectations--and asymmetry in transaction behavior--over $R^S$, the price range of strict static relevance.
2. Transaction asymmetry in behavior appears to be a fact of life. Although with the culmination of an exchange transaction the utility of both parties is enhanced, yet every concession by one during the bargaining stage is a net benefit to the other.

3. It is inherent perhaps in human nature, and also implied in game-theoretic behaviors, to assume that the willingness of an opponent automatically implies the need for a reconsideration on the part of the other. So in effect and even if the sellers are willing to sell all they have at a certain price, once they see a lot of buyers wanting to purchase this product, they withdraw from the market to reconsider.

To summarize, we have thus far shown that when dealing with partial market stability, equilibria can occur with elasticities of expectation of buyers greater than unity, although such equilibria may be very temporary. Prices are not explosive, although they may follow a fluctuating pattern within bounds. Whether or not the expectations of the sellers are elastic or inelastic does not actually affect the qualitative attributes or general nature of the interactions. Inelastic expectations for the suppliers will reduce the destabilizing influence of the elastic expectations of the buyers, but in all probability will not eliminate it, especially in cases where production is not instantaneous.

With the above theoretical but also general discussion of the shape of the demand and supply schedules, we will now turn our attention to the tankship service market and comment on the factors that affect its demand schedule.
APPENDIX TO CHAPTER II

**Interperiod Maximization of Profit or Utility**

We will prove here that the Slutsky-Hicks formulation\(^1\) for the consumer equilibrium in the static case (maximization of utility in any one period), applies also to the case of interperiod substitutions.\(^2\) Namely, we will show that the solution of the \(n\) good case at any one moment of time applies in principle to the case where the choice is between purchases of the same good at \(n\) different points of time, for maximization of utility over a plan covering at least two time periods. This process of budget allocation among periods within a plan, is termed an interperiod substitution.

Let us assume that a consumer attempting to maximize his utility or a producer of some good, uses as input a commodity \(X\). The quantity, \(Q_t\), of \(X\) that he needs at any moment of time \(t\) (for \(t = 0, 1, \ldots, n\)), is derived from his final utility function or the demand of his final product, respectively. The price, \(P_0\), of this input at time \(t = 0\) is determined by market considerations, and so are the prices \(P_1, P_2, \ldots P_n\) at times \(t = 1, \ldots, n\) in the future. On the basis of the relationship between these prices, optimal purchasing plans may be developed given activity budgets and forecasts.

It is assumed here that the final good or utility cannot be produced instantaneously with the mere acquisition of the input, and that the input can


\(^2\)See also Mosak, op. cit., p. 122.
be stored without any significant loss in utility. The latter assumption is necessary for the existence of interperiod substitutions, while the former, although not vital for our arguments, it introduces some realism in the designation of input and output as two different products. Probabilistic uncertainty may be introduced in manufacturing plans, manufacturing time cycles, demand, delivery times, etc., and still not disturb our assumptions of static conditions as long as the type of probabilistic distributions and their parameters are known with certainty. Inventory stocks may thus be established even under static conditions, but purchasing plans will nonetheless be influenced in such cases by the needs of mainly one time period. Under static conditions, the producer will have no reason to deviate consciously from the original plan. Nor would he during any one period purchase more than what he needs for his "current" production plans, unless the $P_i$ of any two periods differ by more than the carrying charges associated with the financing and storing of such excess inventory over the necessary period of time. Once dynamic expectations about future price levels enter into the picture, however, a producer will generally buy more than his current needs if prices are expected to rise and less if prices are expected to fall. So his demand for $X$ may be represented by $Q = K + f(P_f)$, where $K$ is a constant and $P_f$ stands for the future price level. Under strictly static price expectations and stationary demand of the final product that uses $X$ as an input, $f(P_f) = 0$ and $Q = K$.

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1Actually $K$ is a function of present prices, under static conditions. We chose this expositional oversimplification, because we wish to show the impact of dynamic considerations on the static demand schedule (quantity demanded at any moment of time).
For any input purchase plan we assume that the rational producer or consumer will allocate his purchases to the various periods in such a way as to maximize the present value of his profit or utility function.

\[(1) \quad \Pi(Q_0, Q_1, Q_2, \ldots, Q_n) \text{ under the constraint}\]

\[(2) \quad M \geq \sum_{t=1}^{n} P_t Q_t e^{-rt}\]

where \( r \) is the applicable interest rate or cost of capital, and \( M \) is the present value of his monetary resources (owned or borrowed). Under budgetary restrictions where a series of yearly budgets \( B_t \) is available,

\[(3) \quad M = \sum_{t=1}^{n} B_t e^{-rt}\]

The quantities \( Q_t \) that the producer or consumer will buy at the various prices, \( P_t \), will thus be determined by maximizing

\[(4) \quad \Pi + \mu (M - \sum_{t} P_t Q_t e^{-rt}) ,\]

where \( \mu \) is a Lagrange multiplier, and a function of both \( M \) and prices.

At the equilibrium we have:

\[(5) \quad \frac{\partial \Pi}{\partial Q_t} - \mu P_t e^{-rt} = 0 \quad (t = 0, 1, \ldots, n)\]

\[(6) \quad \sum_{t} P_t Q_t e^{-rt} = M\]
which imply that the present values of the net marginal profits imputed to the last units of quantities, \( Q_t \), purchased during the various periods, \( t = 0, 1, \ldots, n \), must be all equal to their prices discounted for \( t \) periods and multiplied by \( \mu \) the marginal utility of money. This is true for all \( t \).

If we designate \( \partial \pi_t / \partial Q_t \) with \( \pi_t \), we then get from (5)

\[
(7) \quad \pi_0 / p_0 = \pi_1 / p_1 e^r = \pi_2 / p_2 e^{2r} = \ldots = \pi_n / p_n e^{nr} = \mu
\]

From (7) we notice that interperiod equilibrium occurs when the marginal rates of substitution, \( \pi_i / \pi_j \), are equal to the price ratios properly discounted.

Equations (5) and (6) will determine the various quantities \( Q_0, Q_1, \ldots, Q_n \) purchased at the various points of time.

Now observe the effect of changes in \( M \) and prices. By substituting

\[
\partial \pi / \partial Q_t = \pi_t
\]

and taking the partial derivative of (5) and (6) with respect to \( M \), we get:

\[
(8) \quad \sum_{t} \pi_t (\partial Q_t / \partial M) - p_s e^{-sr} \partial \mu / M = 0 \quad (s, t = 0, 1, \ldots, n)
\]

\[
\sum_{t} p_t e^{-rt} \partial Q_t / \partial M = 1
\]

Substituting for \( p_t \), in above, \( p_t = \pi_t e^{rt} / \mu \), as derived from (5), we have the equivalent:
By Cramer's rule the solution of the above equation is:

\[
(\frac{\partial Q_t}{\partial M}) = \frac{\mu(D_t/D)}{(t = 1, 2, \ldots, n)}
\]

where \( D \) is the determinant value of the matrix of coefficients in (9) with cofactors \( D_{st} \) and \( D_{st} \).

From the equilibrium conditions we obtain no information concerning the sign of \( D_t \), which implies that with an increase in income the demand for a product may increase or decrease. The latter situation occurs with inferior goods.

Secondly, we take the case where a price say \( P_s \), is increased or is expected to increase all other prices and \( M \) remaining for the moment the same. Again, we substitute \( (\frac{\partial \pi}{\partial Q_t}) = \prod_t \) and differentiate equations (5) and (6) with respect to any \( P_s \) to get:

\[
\sum_t \prod_t (\frac{\partial Q_t}{\partial P_s}) - P_i e^{ir} (\frac{\partial \mu}{\partial P_s}) = 0 \quad (t = 0, 1, \ldots, n), (i \neq s)
\]

(11) \[
\sum_t \prod_{st} (\frac{\partial Q_t}{\partial P_s}) - P_s e^{-sr} (\frac{\partial \mu}{\partial P_s}) - \mu e^{-sr} = 0
\]

\[
\sum_t P_t (\frac{\partial Q_t}{\partial P_s}) e^{-tr} + Q_s e^{-sr} = 0
\]
Substituting \( P_t = \Pi_t e^{tr} / \mu \) in (11) we obtain:

\[
\sum \Pi_{it}(\partial Q_t / \partial P_s) - \Pi_i (1/\mu) (\partial \mu / \partial P_s) = 0 \quad (i \neq s)
\]

(12)

\[
\sum \Pi_{st}(\partial Q_t / \partial P_s) - \Pi_s (1/\mu) (\partial \mu / \partial P_s) = \mu e^{-sr}
\]

\[
\sum \Pi_t(\partial Q_t / \partial P_s) = -\mu e^{-sr} Q_s
\]

We use again Cramer's rule to obtain the solution in terms of \( \partial Q_t / \partial P_s \), which is

(13) \( \partial Q_t / \partial P_s = -\mu e^{-sr} Q_s (D_t / D) + \mu e^{-sr} (D_{st} / D) \)

Substituting relation (10) in (13) and letting \( X_{st} = \mu D_{st} / D \), we get:

(14) \( \partial Q_t / \partial P_s = -Q_s (\partial Q_t / \partial M) e^{-sr} + X_{st} e^{-sr} \)

The above result is nothing more than the Slutsky-Hicks formulation discounted by the appropriate time value of money and for the relevant time periods. The term \( e^{-rs} \) is invariant with respect to both income and prices, consequently relation (14) constitutes a proof that the fundamental equation of value theory applies to the case of interperiod substitutions.

The number of periods depends on the numerical values of \( t \) and \( s \). If we are concerned with the present of course \( t = 0 \).
In relation (14) the first term on the right-hand side gives the income effect of a price change on the demand, and the second, the income-compensated substitution effect. We will use the above equation in the following form:

\[
(15) \quad \left[ \frac{\partial Q_t}{\partial P_s} \right] = \left[ -Q_s \left( \frac{Q_t}{M} \right) + \left( \frac{\partial Q_t}{\partial P_s} \right) \right] = \text{constant}
\]

where

\[
\left( \frac{\partial Q_t}{\partial P_s} \right) = \text{constant} = X_{st}
\]

In (15) we can let \( t = s \) to obtain (16) which gives us the effect of a price change of a good on the quantity demanded in the period that the price change occurred.

\[
(16) \quad \left[ \frac{\partial Q_s}{\partial P_s} \right] = \left[ -Qs \left( \frac{Q_s}{M} \right) + \left( \frac{\partial Q_s}{\partial P_s} \right) \right] = \text{constant}
\]

\[\text{We must always remember that whenever we use this relationship to assess the impact of interperiod substitutions that the terms are appropriately discounted.}\]
Chapter III

The Shape of the Demand Schedule for Tanker Services--Preliminary Comments

In order to obtain an appreciation of the shape of the static demand schedule of tankship services, one must go through several steps of sequential analysis and derivation. Tankship services are adding spatial utility to crude oil, which, in turn, is an input to refined oil. Finally, some of the refined products are intended for ultimate consumer use (for example gasoline is used as an input to consumer transportation and pleasure, and heating oil for comfort) and others are still further inputs to products of various sectors of industrial activity and defense effort. Tankship services, incidentally, enter again at this stage by adding spatial utility to the refined products.

The region of strict static relevance \( R^S \) of the demand schedule for tankship services is, from all indications, very inelastic because of the inelasticity of the demand for petroleum products.

We believe that the demand (short-run and intermediate) for petroleum is inelastic because:

1. Substitution of sources of energy is highly limited because of the heavy capital investment required in converting from one source of energy into another.\(^1\) The cost of oil, therefore, is only a very small fraction of the total cost of the output. As

\(^1\) My former colleague Gordon Shillinglaw informs me that the new generating plants of electric power companies have built-in flexibility that allows substitution of sources of energy. This will make the demand schedule of fuel oil more elastic.
a result, any change in price of oil will have no appreciable effect on the cost of the final product or service, and will not force substitution of inputs.

2. Technical substitutability except in the very long run is usually very low or non-existent. For certain major uses, petroleum and its products have no substitute. Gas turbines and commercial atomic reactors may become competitive with oil-generated power plants only in the very distant future.

3. The structure of the oil industry (institutional-geographical type of constraints) allows the oil companies to pursue, in the short run, production policies that are independent of the cost of any single input factor. The marginal cost of the greatest part of all oil produced is so small, as compared to its final price, that normal increases in the price of inputs, such as tanker transportation, will not possibly equalize prices with marginal costs. This would be particularly true in the aggregate, if oil were free to flow to any market.

The notion of average replacement cost of the capacity used does not enter into managerial decision making, in this particular case, mainly because:

(a) we are concerned with the short run, and an extensive one at that since the productive life of some of the existing oil fields is quite long, and

(b) the range of potential replacement costs is so great, as to render any average meaningless because of the extensive variance surrounding it. Only if we assume that each individual firm faces, because of its own experience, a replica of the statistical universe of the industry will the notion of an average replacement cost be meaningful in managerial decision making.\(^1\)

\(^1\) Even in this case, however, there is no way of knowing whether the "current" replacement cost can serve as a datum for the cost of the particular "future" capacity which will replace the one presently used. In other words, one is not only concerned with the probabilistic distribution, its mean and variance, of replacement costs at any moment of time, but also with the distribution over the means, their average and variance over time.
4. Finally, the existence of regulating agencies and "shut-in" capacities shows that the total demand for oil is inelastic. The price changes that we observe are neither the result of demand elasticity nor of efforts to shift the demand schedule for the industry. These changes are caused by attempts on the part of small operators to enlarge their own share of the market (or to get rid of excess inventories) by regional and seasoned adjustments of oil flows, or by pure miscalculations on the part of some producers. Incidentally, the fluctuations that occur in the product prices do not necessarily imply cost push caused by the raw materials.

On the subject of posted versus delivered prices, it is only fair to mention that things are not as simple as they appear to be. The "net-back" to

There is no doubt that miscalculations do occur often, even with the experts. Data furnished by a few oil companies show their errors in forecasted year to year changes to be as great as 30 per cent to 41 per cent of the actual changes. Even on aggregates, errors of 5 per cent (cumulative) are not uncommon. See: A. F. McIntosh "Petroleum Demand Past and Future" paper delivered to the 1957 annual meeting of the A. P. I. and summarized in the January 1958 issue of the Petroleum Press Service, London, pp. 5-7. Also, one may take the yearly reviews and forecasts of the Transportation Co-ordinator of the Standard Oil Company of New Jersey, which have appeared regularly for several years now in the December issue of The Oil Gas Journal, and compare the forecasts made in one year with the actual results reported in the following year. Because storage is costly and because the marginal cost of oil is low, temptations toward occasional dumping should be expected. This observation particularly applies to small operators whose market share is so small that they hope they can unload before retaliation occurs. On the impact of stocks on prices see: "Massive Improvisation" Petroleum Press Service, January 1957; "The Economic Role of Stocks" Petroleum Press Service, October 1957; "Stockpiling Oil for Europe?" Petroleum Press Service, December 1957, pp. 449-451. Also the "Market Reports" that appear at the end of each monthly issue of the Petroleum Press Service.

the producer does indeed fluctuate, depending on market transportation costs as we have implied in item 3 above, but this statement is true mostly in the case of "marginal" (discriminatory?) sales. Since most sales are covered by long-term agreements, one would only notice the impact of freight rates on these sales, if the accounting system of the producer is geared to register opportunity costs.

Where does all this lead us? It shows that changes in transportation rates may induce changes in other factors but do not decrease or increase the quantity of transportation services demanded in the short run.

In summary, then, we conclude that the region of strict static relevance of tankship services is inelastic because:

1. Transportation is an input to a factor the demand for which is inelastic.

2. Ocean transportation is very specialized; hence, technically the substitution of other input factors for it is close to impossible, especially in static terms.

3. The cost of transportation is only a small fraction of the total cost of the final product that uses it as an input.

4. The institutional and geographical constraints operating in the oil markets allow the operatives to pursue production plans relatively independent of the cost of inputs, especially in the short-run.

1 Most of the crude oil is sold on a delivered basis but yet there is no organized market at delivery points. Consequently in order to determine the impact of transportation rates on the "net back" a producer receives on the "marginal" sales, one has to study the level versus the structure of discounts given. The posted prices at the producing centers are not usually real prices, but only indices on which discounts are given.

5. Changes in transportation costs force other factors to adjust in such a way as to lessen the impact of own price changes on the quantity of transportation demanded.  

So much for the region of strict static relevance of the demand schedule. But is there anything that we can say about the imprint of the dynamic expectations on demand? In particular, can we determine the shape assumed by the demand schedule because of interperiod substitutions? These questions are very vital because we would like to know whether an hypothesis, as expounded in Chapter II, represents empirical reality.

If we simply record the number of transactions completed at the various prices (rates), we will somewhat fail in obtaining a demand schedule for one, or a combination of, the following reasons.

(a) The number of transactions by itself, even though important, is not sufficient since each transaction has more than one dimension. An agreement may cover one voyage for a specified run, consecutive voyages, or an extended time duration. Also size and speed have bearing upon capacity, and this will not be reflected in the number of transactions.

(b) Transactions completed do not necessarily imply quantity demanded at the respective rates. In contrast to the theoretical determination of competitive equilibria, recontracting does not take place in practice, and markets are therefore not cleared. Thus, the completed transactions, however defined, may represent

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1 By impacts of own price changes we mean \( \frac{\partial q}{\partial p} \) (total effect). The latter is contrasted to \( \frac{\partial q}{\partial p_j} \) (total effect) which shows the total impact on the demand for \( x_i \) caused by a change in the price \( p_j \) of another commodity \( x_j \).

2 The reader may also wish to glance over Dr. Koopman's Tanker Freight Rates and Tankship Building, op. cit., pp. 23-49.
only intermediate equilibria achieved by operatives having only partial knowledge of the alternatives. As a result, the completed transactions may not reveal the total impact of the market forces.

(c) Lags may be present, so that the price prevailing in one period may not be the result of factors operating in the same period, but may be influenced by factors of previous or even future periods.

(d) Finally all the other things that are assumed equal under static conditions may not remain equal in practice.

Most of the objections presented under (a) can be removed by translating transactions into time equivalents. This entails the arduous task of converting trips into time duration by taking into consideration the speed of the chartered vessels and round-trip distances. This approximation ignores size and speed differences among vessels on time charter, yet sample checks showed that the "time-cost" of the prohibitive number of calculations necessary for perfection would far outweigh its benefits, and would not change at all the nature of our conclusions. In fact if the refinements were made, they would have accentuated the impact of inter-period substitutions on the demand schedule. As we will later show, during periods of rising prices not only the number of transactions increases but also the average time duration of each contract and the percentage of transportation capacity operating on time charter increase. That is why any refinements will further strengthen the proof of our hypothesis. For these reasons, it was decided for the purposes of this manuscript to stop at the first level of refinement.  

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1 See the chapters entitled "Rates and Transactions" and "The Short-Term Supply Schedule."

2 The size and speed range of tankers over the time period covered by this analysis was not as yet great enough to cause serious problems because of such simplification. Furthermore, the large vessels were not many and most of them were chartered on "private terms."
Overcoming the shortcomings of the data caused by point (b) above is not an easy task, because it is in general virtually impossible to determine the amount of demand that remained unsatisfied at the various prices, especially if such an attempt is made long after the events took place. On the other hand, it may not be necessary for us to make an estimate of such quantities. If the scatter diagram of transactions—either in number or time equivalents—versus rates gives us the expected results, then the most refined cases must do likewise. If we fail in our first approximation, however, then we must find ways to estimate the unsatisfied demand.¹

Luckily, we do have a readily available means for obtaining a more representative demand schedule, than that given by the number of completed transactions. Expectations as we will soon show, affect the tankship building and tankship service markets in the same manner. The difference between the demand schedules of these two markets may be one of degree but definitely not one of substance. The number of orders placed, for new vessels, is more or less representative of the quantity demanded at the various prices, because of the particular short-term notions that apply in these markets. For example, orders are placed for delivery over a period of two to six years. Thus, the supply schedule of shipbuilding is flexible and does not permit price fluctuations as wide as those observed in the tankship service markets. More important, however, is the fact that this flexibility of the supply schedule allows, in the short run, for more orders (almost all) to be accommodated. As a result the effective supply schedule follows approximately the outline of the demand schedule, and the orders placed represent

¹The relationships are not reversible; that is, if the first approximation succeeds, it implies a success for the refined case. If the latter succeeds, however, we cannot conclude that the same thing applies to the first approximation.
more closely the quantities which the owners of tankships demand at various prices. In effect, we are allowed to observe for each price change an approximation of the complete impact of expectations on the quantity demanded before another price change again occurs which in turn will create new expectations, and so on *ad infinitum*.

For measurements of elasticities of demand with respect to future prices\(^1\) (the result of elasticities of expectations), the tankship building markets thus afford a laboratory of great value. This applies of course, to observations concerning the net result of both strictly static and dynamic considerations because, as we have already explained, it is very difficult (as well as of no great practical significance) to separate the purely static from the dynamic effects, as reflected in the effective demand schedule at any moment of time.\(^2\)

---

1 As previously explained, the region of a demand schedule exhibiting the effects of dynamic impacts may be taken by some as reflecting nothing more than the locus of intermediate equilibria established after expectations have caused the demand and supply schedules to shift. But such a distinction is immaterial as long as the demand schedule is never double--valued in such a price region. If such a definition is adopted, however, one must be careful to distinguish between shifts that shape the effective demand schedule outside the region of strict static relevance, and shifts in the total demand schedule (all price ranges, static and dynamic alike). The analysis followed here is still one of comparative statics even though the system is, to use Professor Samuelson's terminology, "dynamic and causal" or "stochastical and non-historical." See Samuelson "Dynamics Statics and the Stationary State," *Review of Economic Statics*, February 1943, pp. 58-68. Also Samuelson *Foundations of Economic Analysis*, Harvard, 1947, Chapter IX.

2 To the extent that we are dealing with derived demand schedules we can assume on the basis of our previous arguments that the own strictly static substitution as well as income effects are negligible. Consequently, the strictly static short-term demand schedule is very inelastic. Hence, the shape of the dynamic shifts in expectations will determine the deviations from the inelastic pattern of the demand schedule.
Finally, if we are given evidences of an elasticity of expectations greater than unity, by time series analysis we may be able to determine whether or not lags are present. In order to overcome any undesirable consequences of the assumptions that everything else remains fixed, we could adjust if it were essential for the major factors that cause shifts in the static demand schedules. One must be careful, however, not to color the impact of price changes, and thus conceal rather than reveal. Often, the factors that operate on the demand schedule may have had their origin in the price movements, consequently adjustments under such circumstances are not only unnecessary but also harmful.

A very important consideration mitigating the impact of other factors in our case, is the excessive speed with which events occur. In a short period of two months tankship rates may change by a factor of seven, so it is rather improbable that external primary effects may be operating on the demand continuously and with such an intensity during this period of time so as to cause such drastic results. Especially when the pattern is repeated over time.

With the above qualifications in mind we will now analyze the relationship between short-term rates and transactions (fixtures), but will return to this topic of measurement later, when we discuss the shipbuilding markets, in order to compare the empirical schedules of tankship service and tankship building demand.
Chapter IV

Rates and Transactions

In this chapter we shall present empirical approximations to the demand schedule for tankship services. In order to obtain a schedule valid for all possible prices, one must choose a time period covering at least one rate cycle.

During the ten years between 1949 and 1958 that we have used for the purpose of this study, the tankship markets went through two complete rate cycles. If we define a cycle as the period from trough to trough, we find that the first cycle lasted from July, 1949, to July, 1954, and the second one from July, 1954, to July, 1958.¹

Because of the time element involved, transactions were tabulated only from July, 1953, to the end of 1958, thus covering only one complete cycle in short-term rates. Since we will later compare this schedule with that of tankship building over both cycles, no information is lost because of such omission. Furthermore, in the course of our analysis in this chapter we will present sufficient information to convince the reader that our conclusions also apply in the case of the July, 1949, to July, 1954, cycle. The sources of the data used are explained in the appendix.

Figure 6 presents a scatter diagram of spot rates versus the number of fixtures transacted. The rates for homogeneity were converted into cents

¹After a short period of false signs of recovery in the fall of 1958, the rates slid again and reached in the summer of 1959 approximately the levels of the summer of 1958. See Davies & Newman Ltd., Tanker Market Report, London, 31st July, 1959.
per 1000 ton-miles carried. Even though no consistent pattern amenable to quantification is observed, yet it is obvious that expectations based on spot rates exercise a considerable impact on the number of fixtures. It will be noticed that the observations plotted in Figure 6 take the rough form of a large numeral "three." Expectations appear to become elastic somewhere between $.90 and $1.10 per 1000 ton-miles. Beyond $1.10 per 1,000 ton-miles, the rates and the number of fixtures are positively correlated, with a turning point in expectations (from elastic to inelastic) occurring around $1.80 per 1,000 ton-miles. A withdrawal from the market occurs between $2.00 and $2.30, with the number of transactions falling from a high of 348 in March, 1956 (333 in May) to 170 in July, 1956. Then comes a zone of uncertainty between $2.30 and $2.70, where expectations fluctuate between elasticity and inelasticity, followed by another turning point and elastic expectations around $2.80 and $3.00. Finally, there is a negative correlation beyond $4.10.

In order to appreciate the relationship between rates and transactions one can trace the time profile of the interactions presented in Figure 6. The loop followed by rates and transactions in 1957 indicates that the demand schedule may not be reversible.

If the above pattern is to be admitted as evidence, it is necessary to make sure that cause and effect are not confused. That is, we must ascertain lest the observed pattern is the result of temporary shifts in demand irrespective of rates, which, if true, will make the fixtures consistently and at all levels rate determining but not rate determined.
To resolve the issues raised in the previous paragraph, we will go through the following simple exercise in logic. First, if the rates reflect the results of temporary shifts in demand (given fixed short-run supply) and are not accompanied by any dynamic considerations, then the charters contracted during periods of high rates should be mostly short-term. Because if the expectations of the operatives concerning the future are unaltered, the number of long-term charters transacted should be negatively correlated with rates, and the rate of shipbuilding activity should not be affected. Indeed, in the case of shipbuilding, the fact that it normally takes between 15 and 25 months to complete a vessel indicates also that there is no reason why an accepted temporary scarcity should lead to future surpluses.

Second, if long-term considerations are involved in the patterns of market behavior, then the consequences of a shift in demand and an increase in rates will depend on whether rate expectations are inelastic, unit elastic or elastic.

Given inelastic rate expectations, an increase in rates due to shifts in demand will postpone rather than increase fixtures, especially charters of long-term duration. At most it may cause an influx of voyage charters, whereupon the operatives will wait until the normal shifts in the supply schedule restore equilibrium. Orders for new ships may be increased, but only up to the point of full shipyard capacity.

Unit elastic expectations will not change interperiod behavior because they leave the relative positions of periodic purchases within a plan unaltered.

If expectations are elastic, the necessary mechanism for cyclical freight rates is established when the initial disturbance occurs. The increase in
rates will generate interperiod substitutions which will make the demand schedule assume a positive slope. In addition, the elastic expectations may generate shifts in demand, which shifts in turn will cause further increase in rates, elastic expectations, interperiod substitutions and so on. Orders for new vessels will be generated also, and a similar cycle will be established in the shipbuilding markets. This process will continue until either expectations change from elastic to inelastic, as operatives recognize their previous error, or new deliveries in vessels cause such shifts in the supply schedule as to decrease rates and, consequently, change expectations.¹

Once rates start falling elastic expectations take over again. Buyers will interpret a fall in prices as signaling future price declines of greater consequence. As a result, at this point the operatives will postpone orders of all kinds, thus prolonging the depression in the tanker service markets and also creating a future tonnage shortage which will give a rise to another disturbance; therefore, a cyclical demand pattern is not necessary to the mechanism of cyclical rates. Changes in demand may bring about a change in the duration as well as in the intensity of the cycle, but will not eliminate it.² In addition, the suddenness and magnitude of the rate changes may influence the intensity of expectations, which, in turn, may influence the amplitude of the cycles.

Turning to more quantitative evidence, we present in Figure 7 the scatter diagram of rates versus fixtures translated into month equivalents, thus

¹Also the process may stop if the inelasticity of the expectations of the sellers and their risk functions are such that they can bring forth enough "short selling" to satisfy the buyers.

²Similar observations were also made by Koopmans for the pre World-War II period. See Tanker Freight Rates and Tankship Building, pp. 148-167.
giving a weight to each transaction approximating its importance. Figure 7 shows a pattern that is not in substance different from that of Figure 6. The overall shape of the two schedules is the same but the fluctuations in transactions, when measured in terms of months of commitments, tend to be greater. For example, the range of monthly fixtures in terms of numbers of transactions is between 85 and 348, while the months of duration vary between 50 and 5250. The full impact of rates on fixtures in terms of carrying capacity is much greater than that shown in Figure 7 because the latter exhibit assumes that vessels on voyage and time charter are uniformly distributed as to size and speed, whereas in fact vessels on time charter are generally larger and faster. Consequently, the validity of any conclusions drawn on the basis of Figure 7 would be greater if the carrying capacity adjustment had been made. Figure 7, therefore, is a "conservative" representation of the effect of rates on fixtures.¹

There is no doubt that the observations in these two exhibits bear the impact of elastic expectations, at least within certain ranges. Not only does the number of all fixtures increase with increasing rates, but also the number of months over which contracts are made. Out of 897 time charters of definite time durations contracted between 1950 and 1957, approximately 66% were contracted at a rate of $1.30 per 1,000 ton-miles and over.² Furthermore, the duration and lead time (time period between the signing of the contract and the delivery of the vessel) show significant differences which

¹We must also remember that during periods of high rates and complete reservation of facilities, a certain amount of unsatisfied demand must be expected. This is another conservative aspect of our empirical schedules.

²Of the 134 transactions that were rejected, only 23 were contracted at rates below $1.30 per 1,000 ton-miles.
strengthen our conclusions. The average time duration over which the contracting parties were bound during periods of high rates was 85 months,\(^1\) while it was only 56 months during periods of low rates. The average number of fixtures contracted per month was 16 at rates of over $1.30, and only 6.5 at rates below $1.30 per 1,000 ton-miles. Variance analysis indicates that in every case the sample means are different at 99% confidence level. Were it not for elastic expectations, such behavior would not have been observed.

With wildly fluctuating time series one cannot very easily distinguish leads from lags. Figure 8 presents the time series of spot rates (1949-1958), the number of time charters transacted between 1950 and 1958, the consecutive voyage charters from August, 1953, to December, 1958, and the total number of all transactions (spot, consecutive voyage, and time charter) completed between August, 1953, and December, 1958. Prior to 1956, data indicate that the charter time series were in approximate phase and moving in the same direction as rates. For the year 1956, however, the data show a tendency on the part of short-term rates to lag behind transactions. Whether this apparent change was due to existing versus anticipated needs

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\(^1\) This means that all the contracts consummated during the Suez crisis will expire during the latter part of 1963. Conceivably the availability of all this tonnage, coupled with the present tie-ups and orders outstanding, may prolong the depression in the tankship markets beyond 1963.
is not clear. There are evidences, however, that the oil companies were
cognizant of the possibility of a Middle East crisis and a Suez blockade
long before they actually occurred.¹ Their consideration of the eventuality
of unrest in the area must have influenced chartering as well as ship-
building activity. Also, many of the time charters contracted during the
Korean War years may have expired early in 1956, thus causing the dis-
turbance needed to set the whole system in motion. We must stress again,
however, that, with elastic expectations, the end result (cyclical movement)
will be the same no matter whether the initial impetus to a rate change
comes from the supply or the demand side.

Finally, let us reiterate that in markets where recontracting does not
exist, the transactions completed do not represent the actual quantities
demanded at the various rates. As shortages develop, the transactions
actually completed conceivably become fewer and fewer as rates increase,
while the excess demand becomes greater and greater as a result of elastic
rate expectations. A possibility such as this cannot be tested with the
data presented here, but will affect the time series in a fashion ap-
proximating that shown in Figure 8.

¹See Petroleum, The Antitrust Laws and Government Policies, S. Res. 57,
pp. 83-84, where it is stated that the State Department was studying in
March 1956, the possible effects of a Suez Canal closure. Undoubtedly the
oil companies were the source of such information to the State Department.
Chapter V

Factors Affecting the Supply of Tankships

A. Introduction

There is little one can do to increase tanker capacity in the short run. Conceivably, operatives could increase the operating speed of tankers and also utilize voyage and port times more efficiently in order to cut down delays. In either case, however, the costs increase sharply and the short-term supply schedule becomes almost vertical beyond the point of full capacity.

If the short run is made somewhat longer, but still not as long as the shipbuilding cycle, capacity may be somewhat expanded by the inflow of dry cargo ships, whalers and grain or ore carriers. These vessels, however, as well as tankers, are specialized means of transportation; consequently, conversion or change of trade is costly. Thus one would expect such conversions to happen only whenever tankship rates are high in relation to rates in the markets from which capacity might be diverted.

The above arguments imply that the only significant changes in capacity occur through shipbuilding activity. In what follows, we shall analyze the factors affecting shipbuilding as a preparatory step to our discussion of tankship rate formation.

In general, the number of orders placed for new vessels will be affected by four main considerations or a combination of such. Although listed separately for expositional purposes, these influencing factors are not necessarily independent of each other. In fact as we will soon point out some of them are vitally interdependent. These factors are:
1. The spot rates (rentals) in the tankship markets and the expectations generated by such rates.

2. The cost of shipbuilding.

3. The rate of technological obsolescence and the age distribution of the existing vessels. Since technology and age determine remaining economic life, they consequently affect retirements and replacements of vessels.

4. The pattern of ownership within the industry as colored by the existing institutional considerations. Often, the existing capacity for the industry may be more than sufficient at any moment of time but new orders may be generated by the desire of the operatives either to change or to sustain their share of ownership.

Tanker rates are the motivating force behind each of these factors. However, the impact of rates on new orders differs, depending on the medium through which such impact operates. For this reason, the discussion of the factors that influence new capacity will be separated into three broad classifications. One to consider the impact of spot rates and shipbuilding costs, another to analyze the influence of economic life expiration on replacements, and finally there will be a section to consider the influence of institutional factors.

**B. Spot Rates, Shipbuilding Costs and Orders Placed--Theoretical Formulations**

The number of orders placed is closely related to the spot rates, suggesting that movements in spot rates shape expectations about the future. Spot-rate-induced expectations also indirectly affect the elasticity of expectations with respect to the level of shipbuilding costs through their effect on orders placed. We may thus define:
(1) \[ O_t = f(R_s, C_s) \]

where \( O_t \) stands for orders budgeted for period \( t \) and \( R_s, C_s \) stand for the spot rates and cost of shipbuilding respectively, both in the short run.

If we assume that the function can be differentiated, we can approximate the change in orders placed because of changes in spot rates and the cost of shipbuilding by taking the differential of our function.\(^1\)

Then:

(2) \[ \left[ \frac{\partial f(R_s, C_s)}{\partial R_s} \right] \Delta R_s + \left[ \frac{\partial f(R_s, C_s)}{\partial C_s} \right] \Delta C_s \]

For small changes, increments \( dR_s \) and \( dC_s \) may be defined as:

(3) \[ dR_s = \Delta R_s \quad \text{and} \quad dC_s = \Delta C_s \]

Each price change is accompanied by two effects on the demand of a particular commodity, the income-compensated substitution effect and the income effect.

The income-compensated effect of the first term on the right-hand side of (2) can be alternatively expressed as (ceteris paribus):

(4) \[ \left( \frac{\partial f(R_s, C_s)}{\partial R_s} \right) dR_s \]

\(^1\)The differential is really the principal part of the infinitesimal change in \( f(x,y) \) due to changes of \( \Delta x \) and \( \Delta y \) in the independent variables \( x \) and \( y \). The total change is given by:

\[ \Delta f(x,y) = \left[ \frac{\partial f(x,y)}{\partial x} \right] \Delta x + \left[ \frac{\partial f(x,y)}{\partial y} \right] \Delta y + \xi_1 \Delta x + \xi_2 \Delta y \]

where \( \xi_1 \) and \( \xi_2 \) are infinitesimals approaching zero with \( \Delta x \) and \( \Delta y \).

The differential is defined as the first two terms of the right hand side. As for the error involved in neglecting \( \xi_1 \Delta x \) and \( \xi_2 \Delta y \), one can estimate it by applying Taylor's theorem.

\(^2\)Notice that \( \Delta x \) and \( d_x \) are arbitrary increments of \( x \), with no assumptions made as to their exact magnitude.
(5) \[ E_{t',t} R_s O_t/R_s dR_s \]

(6) \[ O_t E_{t',t} R_s R_s \]

where \( E_{t',t} R_s \) stands for the spot rate elasticity of demand for tankship orders, other things equal, and \( R_s = dR_s/R_s \)

Notice that relation No. 6 is not the static substitution effect of the Fundamental Equation of Value Theory (Slutsky-Hicks formulation). If our relationship were \( X_{rs} \), namely the static income-compensated substitution effect on the demand for new shipbuilding due to a change in spot rates, then, because of symmetry, \( X_{rs} \) would be equal to \( X_{sr} \) or \( \partial X_s/\partial p_r = \partial X_r/\partial p_s \). This relationship does not exist, however, in the shipbuilding and ship service markets. First of all, ordering new ships and renting on spot for a single voyage are neither substitutes for each other, nor, from the static point of view, complements. Many such single voyage cycles will be completed before the new ships which are ordered appear in the market. Hence, for the case considered here, \( X_r \) (orders for new vessels) and \( X_s \) (spot charters) are complements only indirectly through dynamic expectations. Furthermore, and even if we were

\[ \text{1Hicks, Value & Capital, Mathematical Appendix, pp. 307-313. Also R. G. D. Allen, Mathematical Economics, Macmillan & Co., 1957, Ch. 19. For our purposes } X_r \text{ stands for new orders, } p_r \text{ for the cost per deadweight ton for building a vessel, } X_s \text{ for spot charters and } p_s \text{ for spot rates.} \]
considering long-term rates, only by making the additional assumption that the lead time from rental contract to ship delivery is the same as the lead time from ship construction contract to new ship delivery could the orders for new vessels and the long-term charters be considered as substitutes in static terms. And this consideration could only be applicable to the oil companies. Let us not forget, however, in conjunction with the last qualification that over 60% of all tonnage is owned by the so-called independents. Furthermore, our assumptions about equality of lead times and charter durations are extremely unrealistic.

In terms of total market demand, therefore, shipbuilding and ship services both in the short and in the long run, will be found to be complementary because of dynamic anticipations. After all, the demand for shipbuilding is derived, ships being the only inputs of importance to ship services. This complementarity, however, does not necessarily imply that there is a static income-compensated substitution effect \( X_{rs} < 0 \), unless we assume an applicable demand schedule of the traditional negative slope. The latter assumption, however, we found to be meaningless and repudiated by empirical reality. Furthermore, we have seen that our \( X_r \) and \( X_s \) (new ships and ready ship services) are meaningfully related only in the dynamic sense. In order to show the latter interrelationship, we can restate equation No. 6, as follows using the formulations developed in Chapter II.

\[
(7) \quad \left[ \frac{\partial f(R_s, C_s)}{\partial R_s} \right] dR_s \tau = \text{const.} = 0 \quad E_{b} E_{t} R_{f} R_{s}
\]

where \( E_{b} \) is the rate elasticity of expectations of buyers.

---

\(^1\)To be exact, the rate applicable to a charter of duration equal to the life of a new ship.
The preceding relationship (No. 7) is positive or negative, depending on \( E_b \) and \( E_{O_t,R_f} \) and gives us the impact of dynamic expectations on orders because of shifts in the investment opportunity schedules. In our case \( E_b \) is greater than one, consequently \( E_{O_t,R_f} \) is positive and the whole income-compensated substitution effect is positive.

In addition to the dynamic effects of changes in spot rates on orders placed, given by (7), there is also a static income effect comparable to that of any other price change. This is expressed as:

\[
(8) \quad I_{R_s} = \left( \frac{\partial I}{\partial R_s} \right) \left( \frac{\partial O_t}{\partial I} \right) dR_s
\]

Under fixed budget assumptions:

\[
\frac{\partial I}{\partial R_s} = F_t, \text{ the present available fleet}^1
\]

and

\[
E_{O_t,I_R} = \left( \frac{\partial O_t}{\partial I} \right) (I/\partial I) \text{ Consequently relation (8) becomes:}
\]

\[
(9) \quad I_{R_s} = F_t (O_t/I) E_{O_t,I_R} dR_s
\]

where \( E_{O_t,I_R} \) represents the income elasticity of orders due to changes in rates.

Turning now to the second term on the right-hand side of relationship (2), we can derive a relation similar to (7) for the effect of shipbuilding costs on new orders placed.

\[\text{^1The relationship is positive because a rate change will increase rental incomes of available vessels.}\]
(10) \[
\left( \frac{\partial f(R_s, C_s)}{\partial C_s} \right) \frac{dC_s}{\tau} = \text{const.} = \left( \frac{O_t}{C_s} \right) E_{O_t}C_s, \quad dC_s
\]

(11) \[
= O_t E_{O_t}C_s, \quad \bar{C}_s
\]

(12) \[
= O_t E_{O_t}C_f, \quad \bar{C}_s
\]

where \( E_{O_t}C_s = (\bar{O}_t / O_t) (C_s / \bar{C}_s) \) represents the present price (cost) elasticity of demand, ceteris paribus, \( \bar{C}_s = dC_s / C_s \), \( E_b \) the price elasticity of expectations\(^1\) and \( E_{O_t}C_f \) the elasticity of demand with respect to future shipbuilding costs.

Relation (11) gives us the substitution effect (income-compensated) caused by changes in the cost of shipbuilding (own price effect). In the case of tankers this static substitution effect--as it refers to substitution of another commodity for tankers in period \( t \)--is virtually nil. However, there is an interperiod substitution caused by the elasticity of expectations which will affect the orders of one period versus another. If expectations are elastic, the substitution effect is positive;\(^2\) if they are inelastic, it is negative. This result is shown more clearly in relation (12).

---

\(^1\)Because the two markets which we are analyzing are related, we assume that the coefficients of expectations are the same in both. If not a proper identifi-

\(^2\)This does not necessarily imply that the shape of the static indifference curves is different from what we naturally expect it to be, namely concave up. Here \( \bar{O}/\bar{C}_s \) evidenced in static terms is really equal to \( (\bar{O}/\bar{C}_f)(\bar{C}_f/\bar{C}_s) \)

where \( C_f \) = expected future costs. If we limit ourselves to periods \( t \) and \( t + 1 \) only, \( C_f \) is the cost for \( O_{t+1} \). Therefore \( O_t \) and \( O_{t+1} \) are substitutes.
The income effect of a shipbuilding cost change on the demand for new vessels is:

$$I_{Cs} = \frac{\partial I}{\partial C_s}(\partial O_t/\partial I) \, dC_s$$

Given again a fixed budget:

$$\frac{\partial I}{\partial C_s} = - O_t$$

and:

$$I_{Cs} = - O_t \, (O_t/I) \, E_{0_tI_C} \, dC_s$$

where $E_{0_tI_C} = (\partial O_t/\partial I)(I/\partial I)$ or the income elasticity of orders due to changes in the cost of shipbuilding.

The above income effect is only static\(^1\) and always negative because new tankers are not an inferior commodity.\(^2\)

If we now consider the total effect on new orders which are brought about by changes in shipbuilding costs, we notice that the substitution effect (No. 12), which is expected to be positive, may be offset by the negative income effect (No. 14). The direction of the net effect will thus depend upon the size of the shipbuilding budget, the coefficient of expectations and the change in orders placed with respect to the change in real income, all other things being equal.

\(^1\) Notice that the relevant income effect rules over the budget plan.

\(^2\) Our previous observation on the behavior of the oil companies when charter rates are low (which behavior gives rise to Giffen's paradox similarities) refers to tanker service availability, not shipbuilding. What is more, the relationship is asymmetric. The positive sign of the income effect in the tankship service markets arises, in the case of the oil companies, not because both $(\partial I/\partial R_s)$ and $(\partial Q/\partial I)$ are negative, but because both are positive. This shows that the input may be price determining rather than being itself determined by the price of the final product.
In summary, the direct expected impact of changes in spot rates and construction costs on orders placed during a period is expressed by:

\[
\mathcal{E}(R, C) = E_t R_t F_t(0/I) E_t I_t(R_t C_s) 
\]

(15)  \[ + O_t E_t R_t C_s C_f = O_t(0/I) E_t I_t(R_s C_s) \]

where \( E_t I_t = E_t C_s = E_t I_t \)

Relation (16), as defined, shows that the value of \( df(R, C) \) depends on two interperiod substitution effects and two static income effects. These substitution effects are due to the expectations as shaped by the movements in the spot rates and the cost of shipbuilding, respectively, and are positive or negative depending on the sign of the elasticity of expectations. If expectations are elastic, and there are many indications that this is the case, then the two terms are positive.

In terms of absolute magnitude, we expect \( E_t R_t \) to be greater than \( E_t C_s \) because of the higher volatility in spot rates as compared to shipbuilding costs.

\[^1\text{Notice that in real life the various } E_i \text{ may not be equal. If, for example shipbuilding is granted a fixed budget on the basis of a total overall budget, given price relationships, production possibility schedules and expectations as of that moment of time, any real income effects due to changes in } C \text{ may affect only the shipbuilding budget. On the other hand, since the cost of transportation is part of the delivered product cost, the income effects of a change in } R \text{ will affect the overall budget and thus may result in } E_t I_t \text{ being less than } E_t I_c.\]
The two static income-effect terms oppose each other, and this is clearly evident in \((F_t dR_t - Q_t dC_t)\). As we have seen, changes in spot rates not only affect dynamic expectations in such a way as to shift the investment opportunity schedules, but they also affect the current incomes of those who control tankship capacity. This income effect, which is proportionate to the tankship capacity controlled not necessarily owned, generates more orders.\(^1\) The other income effect is definitely negative and is due to changes in the cost of shipbuilding. Its magnitude depends on the shipbuilding budget and the income elasticity of orders placed. The net result on new orders will depend upon whether the people operating in these markets feel richer because of the increase in rentals or poorer because of the increase in the cost of their capital equipment.

Because the demand for shipbuilding is derived, we do not expect the income elasticity to be very significant. Rather, we expect orders placed to be relatively inelastic with respect to income. In either case, as long as short term rates increase \((dR > 0)\), the net result of the two income

\(^1\) Notice that the independents will not benefit by an amount proportionate to the capacity that they own, but only to the extent of the capacity they have available for charters. In contrast the oil companies will benefit by an amount proportionate to the capacity they own or have under charter (if such capacity is not engaged in transporting oil on a delivered basis under old contracts), minus the differential they will now have to pay to cover existing tonnage deficiencies.

Even though during periods of high rates one would expect to find that most of the orders placed because of the income effect to come from the oil companies, in actuality this is not the case. As a result of the financial agreements that the independents are willing to negotiate, the benefit to the independents is in proportion to both the capacity they now have available for charters and the capacity they will have. Physical delivery of the ship may run anywhere from months to years (in one case, over ten years), and agreements are sometimes made for ships that do not exist, even on the drafting board.
effects is expected to be positive, since $F_t$ is normally greater than $O_t$, and $dR_s$ is normally greater than $dC_s$. Both $dR_s$ and $dC_s$ move in the same direction, so our statements relating to their respective magnitudes are valid in absolute terms.

As equation (15) shows, then, the most important factors influencing orders placed are the elasticities of expectation generated by the movement in short-term rates. Only a reversal in rates can arrest the flood of orders. The conditions under which such a reversal can occur were analyzed in Chapter II. The cause and effect manifestation, of course, is not instantaneous. It takes time, and orders may lag behind spot rates by a few months; but we shall come back to this point later.

Before closing this discussion, we must mention that changes in $C_s$ may be expressed as an implicit function of $R_s$. There is strong evidence that such a relationship exists, especially when shipbuilding is beyond the full capacity point. Because of the latter qualification, we feel that it is better to consider $C_s$ as an independent variable. Our formulation, however, can be adapted to account for a change of $C_s$ from an independent to a dependent variable by multiplying the two effects caused by changes in the cost of shipbuilding by $(\frac{\partial C_s}{\partial R_s})$ or $(\frac{dC_s}{dR_s})$, depending on whether or not $C_s$ is considered as dependent only on $R_s$.

---

1 Figure 15 shows that at its peak $O_t$ was 96% of $F_t$, in September 1957 (aftermath of the Suez crisis). However, not all of the existing fleet was available for rechartering, or recontracting.

2 It is safe to claim that on the average $dR_s$ is at least twice as great as $dC_s$.

3 During periods of excess capacity, a more sophisticated dynamic system is needed to express the relationship between $C_s$ and $R_s$ in terms of the number of years of orders carried on the books of the shipyards.
C. Retirements and Replacements--Theoretical Discussion

The number of orders placed will also be affected by the retirement program (scrapping) for old and obsolete vessels. This rate of scrapping is really a function of three main considerations:

1. The age distribution of vessels as of a moment of time.
2. The rate of technological change and the rate of introduction of such.
3. The level of expected charter rates.

At the outset, we must stress that the analysis of this section is an approximation of a much more complicated formulation that involves present values. The simplified analysis is preferred, however, for purely expositional purposes, because it is easy to follow. A more sophisticated method is included in the last footnote to this section.

An uneven age distribution in the existing fleet will create uneven replacement programs, other things being equal. In the absence of technological change, given expectations of long-term remunerative rate, a ship will be replaced if, and only if,

\[ TC_1 - AVC_o < 0 \]

where \( TC_1 \) represents the total cost per unit of capacity of a new ship similar to the one to be retired and \( AVC_o \) represents the average variable cost of the old ship.\(^1\) This argument assumes that the average variable cost of a ship increases with age.

\(^1\)The \( TC_1 \) includes the cost of capital and takes into consideration any trade-in or scrap value of the old ship; \( AVC_o \) considers, also the cost of lay-up in case the ship is now, or is expected to be, idle.
Technological obsolescence will affect replacement programs if it results in a total cost for a new ship (not necessarily similar to the one whose replacement is contemplated) lower than the average variable cost of the existing ship:

\[ TC_j - AVC_o < 0 \]

If \( TC_j \) is less than \( TC_i \), a ship will be replaced even though \( TC_i - AVC_o > 0 \).

Low spot rates will accelerate retirements during depressed periods if the current rate, \( R_o \), is lower than \( AVC_o \), and the expected revenue per unit of remaining capacity is lower than \( AVC_m \), where \( AVC_m \) represents the average variable cost over the longest possible physical life as contrasted to economic life. To the extent that \( AVC \) increases with age, \( AVC_m \) will be greater than \( AVC_o \). Consequently, if the expected revenue per remaining unit of capacity is lower than \( AVC_o \), such revenue will certainly be lower than any \( AVC_i \).

Therefore, even if \( TC_i > TC_j > AVC_o \), the vessel will be scrapped if the expected revenue will not cover the out-of-pocket costs per unit of remaining capacity (that is, \( R_m < AVC_o \)). However, given \( R_m < AVC_o \), a replacement will not be ordered unless either \( TC_j < R_m \), or the expected rate \( R_m \) is an intermediate rate that will govern only over a period of time not greater than the life of the existing vessel. As long as the long-term rate, \( R_l \), is greater than \( TC_i \) or \( TC_j \), then an order for replacement will be initiated sometime in the future. Nevertheless, the relationship between \( R_m \) and \( R_l \) will determine the timing of the replacement order.

For example, if \( R_m = R_l > TC_j \), then the replacement order will be initiated
at once; if, on the other hand, \( R_m < TC_j > R_1 \), the new order will be placed if, and only if, the period over which \( R_m \) is expected to rule is less than or equal to the shipbuilding lead time, \( t_s \), and provided that the average variable cost of the old ship \( AVC \) over \( t_s \) is greater than the total cost per unit of capacity of the new ship \( TC_j \).

Formalizing the above argument, we observe that, of the eight different interrelationships between \( TC_j \), \( AVC_t \), \( AVC_o \), \( R_m \), and \( R_1 \), the following three cases are important. If (a):

\[
TC_j > AVC_t
\]

and \( R_m < AVC_o \)

and \( R_1 > TC_j \)

then the old ship will be scrapped. An order will be placed, however, only if the low rate \( R_m \) is not expected to rule over a period exceeding the shipbuilding lead time \( t_s \). (This of course implies \( t_s = m \) because if \( t_s \) is greater than \( m \), then, depending on the tie-up costs, it may be advisable to keep the old vessel, since \( TC > AVC_t \).)

On the other hand, if (b):

\[
TC_j < AVC_t
\]

and \( R > AVC_o \)

and \( R_1 > TC_j \)

the old ship will not be scrapped, but an order will be placed. Scrapping of the old ship will await the point at which \( AVC \) exceeds the expected rate, \( R_m \).
Finally, if (c):

\[ TC_j < AVC_{t_s} \]

and

\[ R_m < AVC_o \]

and

\[ R_l > TC_j \]

then the old ship will be scrapped and an order will be placed only under

the same conditions that we stated in (a).

All the other possible relationships are either inadmissible (four of
them imply \( R_l < TC_j \)) or else are of no interest to us (for example

\[ TC_j > AVC_{t_s}, R_m > AVC_o \text{ and } R_l > TC_j \]).

If \( R_l > TC_j \), then in every case orders are placed when either

(i) \( TC_j < AVC_{t_s} \)

of

(ii) \( R_m < AVC_o \)

and \( AVC_{t_{s+1}} \rightarrow R_{m+1} \rightarrow TC_j \) for \( m \rightarrow t_s \)

If the rates in the short run are lower than \( AVC_o \) and the ship is laid
up, its average variable cost increases by the average variable cost of the
lay-up. This condition, in effect, causes \( TC_j < AVC_{t_s} \) (even in cases where
the average variable cost of the old ship, excluding tie-up cost, is lower
than \( TC_j \)), and thus hastens retirements and new orders.

The above discussion shows that initially a certain number of orders
\( Q_a \) will be placed purely because of the age of the existing vessels. We
have noticed, however, that charter rates may either prolong or hasten this replacement point because, if a ship is to stay in operation, \( R_m - AVC_o \) must be positive. ¹ The lower (or higher) \( R_m \), other things equal, the sooner (or later) a vessel will be retired (kept or in service) given the fact that \( AVC_t \) increases with \( t \).

In addition to \( Q_a \), a quantity \( Q_T \) will be ordered because of technological considerations. Obsolescence cuts the economic life of vessels, and retirements take place earlier than originally expected. The criterion that determines replacement in this case is the difference between the total cost per unit of capacity of the new ship and the average variable cost of the old vessel. As in the case of \( Q_a \), the expected charter rates will also affect \( Q_T \). For those vessels that are already tied up or are expected to be tied up because of low rates, the average variable cost per unit of remaining capacity is increased by the average idle and recommissioning cost \( AIC \), thus accelerating retirement.

The question, of course, is how this impact of replacements affects our previous formulation as expressed in relationship (16). When rates are high and the fleet is employed, expectations will in all probability overshadow any other consideration, and equation (16) will govern. Under such circumstances, the relevant \( Q_a \) will be included in the quantities ordered because of the dynamic substitution effects. Such a contribution will be over and above any purely speculative quantity. In addition, a part of

¹For the shortest short run, a vessel may be kept in operation if \( R_s - (AVC_o -MIC)>0 \), namely, as long as the short-term rate plus the expected marginal idle costs are greater than the \( AVC_o \). Keeping the vessel in operation under such circumstances is a distress measure and applies only in cases where \( R_t \) for \( t>s \) is expected not only to cover \( AVC_t \), but also to compensate for previous out-of-pocket losses.
Q_T will be involved, which is determined by TC_j - AVC_{t_s} < 0, where AVC_{t_s} does not include any tie-up costs, since remunerative employment exists.

When rates are low, however, both Q_a and Q_T will be greater than they would be at high rates. What determines the size of replacement orders in this case is the difference between the total cost of the new ship and the average variable cost of the old one, where the average variable cost of the old ship includes also the expected average idle cost. Namely, a vessel will be replaced if: TC_j - (AVC_{t_s} + AIC_{t_s}) < 0, where AIC_{t_s} represents the expected average idle and recommissioning cost over the period t_s (shipbuilding lead time), provided, of course, that R_{t_s+1} > TC_j. It is to be expected that the "profit squeeze" imposed by low rates will force the operators to introduce cost-saving technological innovations, thus eliminating all the inefficient units under their control.

To complete relationship (14) we must add the following term, which covers the increase in orders caused by retirements or scrappings (S)

\[
\begin{align*}
\mathcal{O}_t/\mathcal{S} = \sum_{i=1}^{n} V_i c (AIC_{t_s})_i \left[ (AVC_{t_s} + AIC_{t_s})_i - TC_j \right]
\end{align*}
\]

provided that AVC_{t_s+1} \left( R_{t_s+1} > TC_j \right)

In the above expression, \( \sum_{i=1}^{n} V_i \) represents all the vessels which cannot find remunerative employment and whose average variable cost plus average idle cost during t_s is greater than the total cost of their expected replacement. The first factor (AIC_{t_s}) guarantees that the whole term will be zero if the short-term rates cover out-of-pocket costs and the
ship expects to stay employed. Finally, \( c \) is a scalar which determines whether the unit of measurement for replacement is ton for ton or not. The provision that \( \frac{AVC_{t + 1}}{R_{t + 1}} > \frac{TC_j}{c} \) is to guarantee that upon completion of the new vessel, its expected charter rate will at least cover its full cost, a requirement that must be satisfied before undertaking to build a new vessel. Furthermore, to replace the old vessel it is necessary for the expected total cost per unit of capacity of the replacement to be lower than the expected average variable cost per unit of capacity of the vessel to be replaced. The latter comparison is only valid over the period during which the old vessel was expected to be employed.¹

While on the subject of technology, we must mention that its effect in the tankship service markets is surplus producing. Namely, the value of scalar "\( c \)" in relationship (17) is greater than one. In industries such as this in which the technological economies of scale are so pronounced, surplus is the natural consequence of the general increase in the size of the most efficient units. For example, during 1956-1958, the average size of the ships on order was twice that of the ships in operation. Obviously then, one-for-one replacement introduces a much greater capacity than is needed, especially when it occurs in periods of depressed markets and excess tonnage. Owners who contemplate replacements of more than one unit will undoubtedly attempt to reconcile capacities, but there are many owners of one or a few vessels, and replacements by these owners will expand capacity. Furthermore, the replacement may have to be one-for-one, if the vessels must operate in dispersed geographical locations at the same time.

¹See page 91
In practice, the problem is not as simple but, in general, one can adapt economic tools (see Fisher, The Theory of Interest, Macmillan, New York, 1930, especially Chapters VI, VII, VIII, for his "second approximation") for purposes of alternative decision-making in every day reality. For example, given: $R_t$ and $R'_t$ as the rate per unit of capacity expected in period $t$ for the old and the new vessel respectively; $C$ and $C'$ as the respective capacities $AVC_t$ and $AVC'_t$ as the average variable (out-of-pocket) costs per unit of capacity in period $t$ for the old and the new vessels; $n - m$ the expired life of the old vessel; $S_o$ the present scrap value of the old vessel; $S_m$ and $S_m'$ the values of the old and new vessel respectively $m$ years from now, if any; $r$ the subjective rate of return; $K$ and $K'$ the initial investments in the two vessels respectively; then initially for each alternative to be considered we must have:

1. $\sum_{t=1}^{m} C(R_t - AVC_t)e^{-rt} + S_m e^{-rm} - S_o > 0$

and

2. $\sum_{t=1}^{m} C'(R'_t - AVC'_t) e^{-rt} + k e^{-rm} - K' > 0$

In order to choose the new over the old, the following must hold:

3. $\sum_{t=1}^{m} \left[ C'(R'_t - AVC'_t) - C(R_t - AVC_t) \right] e^{-rt} + (k_m - S_m) e^{-rm} - (K' - S_o) > 0$

If $R'_t = R_t$ the above simplifies to:

4. $\sum_{t=1}^{m} (CxAVC_t - C'xAVC'_t)e^{-rt} + (k_m - S_m)e^{-rm} - (K' - S_o) > 0$

The previous relationship represents the first approximation of the present worth of economic value (under certainty); but in order to apply to present-day reality we must further adapt it to reflect the impact of taxes, because the government for tax purposes recognizes the accrual principles of income determination, which principles distinguish between cost and amortized expense, and also between realized and deferred income. Thus (4) above under straight line depreciation becomes:

5. $\sum_{t=1}^{m} (CxAVC_t - C'xAVC'_t)e^{-rt}(1-Tax\ Rate) + \left[ (Kxm/n) - S_o \right] (Tax\ Rate) + (k_m - S_m)e^{-rm}$

\[ + \sum_{t=1}^{m} (k'/n' - K/n)e^{-rt} (Tax\ Rate) - (K' - S_o) > 0 \]

Relation (5) may be further modified to reflect probabilistic uncertainty, but such modification of necessity will be based on individual value judgments and will in no way alter basic premises of decision making.
Summarizing the results of relationships (16) and (17), if expectations are uniformly inelastic, a negative correlation should be observed between short-term rates and orders placed. The lower part of the demand schedule will be more elastic because of relationship (17). At very high rates (still under the assumption that expectations are inelastic) the positive income effect of one of the two income terms may give the schedule a positive slope if it counterbalances all the other effects, but such an occurrence is very improbable; as can be attested by examining relationship (16). If, on the other hand, rate and shipbuilding expectations are uniformly elastic, the demand schedule for orders will definitely be of positive slope (up to the point $O_dC_t$ counterbalances all the other terms at very large $O_t$) with the exception of its lowest part, which may show "schizophrenic" tendencies due to the opposing effects of relationships (16) and (17). Orders placed at very low rates may thus oscillate for a while intermittently until the effects of the replacement programs of inefficient vessels exhaust themselves and also the positive effect of the term $O_dC_t$ is satisfied. Finally, if the expectations of those operating in the tankship markets are not uniformly elastic, the "demand" schedule of orders placed will change from one of positive to one of negative slope around the points where the expectations schedules change from elastic to inelastic.\footnote{As we have previously shown in Chapter II, the assumption of expectations schedules of non-uniform elasticity is not necessary for the final turning points (top and bottom) of the demand schedule. The income effect will eventually take over and give a negative slope to the demand schedule even under uniformly price-elastic expectations.}
D. The Pattern of Ownership--An Institutional Paradox

Our previous statements concerning replacements must now be qualified to allow for variations in the pattern of tanker ownership. If the tanker ship markets were purely competitive\(^1\) under a stationary state and with ships of equal age and size evenly distributed among the many owners, one would need only look at the aggregate quantities to determine market behavior. That is, it would be possible to determine the number of new orders needed to meet the stationary state requirements by examining the total existing fleet. The same is true in the case where the markets are highly organized. Then a central agency can co-ordinate the number of orders placed in order to meet the total requirement for transportation and at the same time avoid unwanted surpluses.

Unfortunately, however, the problem is more complicated. While it is true that no single owner owns more than approximately 7% of the total capacity (see Table 1), yet approximately 34% of the present total capacity (for vessels of 6,000 DWT.) is owned by oil companies. This, in effect, introduces an imperfection, because employment for this tonnage is not secured competitively.\(^2\) Conceivably, some or all of the oil companies for reasons purely known to themselves, could at any time, decide to increase their share of the total tonnage (own more and charter fewer ships from the independents) while the total market abounds with surpluses. Namely, decisions by oil companies to purchase additional

---

\(^1\)Later on we will introduce an extensive discussion on the organizational behavior of tanker markets. See chapter entitled "Characteristics of the Tankship Markets."

\(^2\)As previously mentioned, only in times of surpluses does this tonnage compete directly in the market.
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### Independent Companies

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### Total Independent Companies

| Total              | 1,713         | 2,055.8|

### Government Commercial

| Total              | 86             | 63.7   |

### Total World Commercial

| Total              | 2,703         | 3,167.2|

### Membranum Totals

<table>
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<table>
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tonnage may be made independently of current aggregate market conditions.¹

When their long-term needs are greater than the capacity controlled, the oil companies have the choice of ordering vessels or securing tonnage on long-term charter, regardless of any surpluses that some other owner may or will have.²

The impact of changing technology and the age distribution of vessels owned by the independents and the oil companies may again, in the absence of any "regulating agency," generate orders while surpluses exist in the aggregate. Table 2 shows that an age disproportionality of vessels exists with the various owners, as well as in the aggregate. Other things being equal, lumpiness in orders placed should then be expected, which, in turn, will affect future replacements. Given normal conditions and a mature industry, new orders greatly depend on deliveries made twenty or so years ago.

For the reasons discussed here, orders were being placed during the post-Suez period while cancellations were mounting. For example, during

---

¹In the general case, this claim may not be technically correct. In some cases the decisions to increase ownership shares is aimed at mitigating the conditions that have caused the undesirable market situation and uncertainty. But in so doing the oil companies aggravate rather than improve the situation, because they enter into the market exactly when they should have stayed out. Furthermore, the oil companies cannot succeed in eliminating these undesirable conditions, given the many uncertainties surrounding their forecasts of oil demand as well as the geographic sources of oil supply. See Koopmans' Tanker Freight Rates and Tankship Building, Part III (Section 8).

²The magnitude of this choice on the part of oil companies is really limited. Certainly they cannot afford to have enough vessels for their maximum expected needs because of the costly surpluses of tonnage thereby created. Such surpluses benefit only the small oil producers who do not own transportation facilities. Furthermore, to the extent that we expect the relative needs of each individual company to fluctuate more than those of the industry, the "independent" tankship market is necessary for pooling the risks inherent in such uncertainties and its elimination will be very costly for the oil companies and the industry.
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</table>

**Memorandum Totals**

- Included in above figures:
  - Independent Norwegian Owners
  - Independent Greek Owners

- Not included in above figures:
  - Government Military
the first half of 1958, orders were placed, mostly by oil companies, for a total of 1,7500,000 DWT. while cancellations must have been close to five million tons, giving a net decrease in new orders placed of approximately 200 T-2's. Also, for the second half of 1958, 1,400,000 DWT. of new orders were placed, but cancellations brought the net new orders placed down to only 1.3 T-2's.2

The impact of the institutional considerations discussed here is expected to manifest itself only on the down-swing. When rates are high and expectations elastic, the whole industry behaves in only one fashion. Each owner places orders because others have begun ordering, and no one thinks of costs and prices. With rates low, however, the soul searching and re-examination begins. It is exactly at this stage that the institutional factors enter.

The oil companies dislike low tanker rates mainly because rate depressions disturb their long-term contractual bargaining. Furthermore, under depressed market conditions the oil companies do not "realize" any return on their tankship investment. If most of the oil produced by a particular

---

1It seems that the oil companies follow the independents advantageously on the down-swing but disadvantageously on the up-swing. The independents, because of their flexible organizational structure, react faster.

2These figures for orders placed are derived from J. I. Jacobs World Tanker Fleet Review, 30th June 1958, p. 2, and 31st December 1958, p. 4, and Table 10. The figures refer to vessels of 10,000 tons dead-weight and over.

It must be stressed that our figures refer to tanker cancellations only. In addition to cancellations, orders may also be either converted to dry cargo orders or postponed. Usually postponements are another dimension of cancellations, because those who place the orders may request such postponements in periods of uncertainty until the market trends become more definite.
company is sold on a delivered basis and the company successfully resists pressures for renegotiations of old contracts and discounts, then the low rates on any new charters transacted will affect favorably the total profits of an integrated firm. This profit, however, will all be imputed to the production activity, and this will be of little consolation to the managers of transportation departments who operate under budgetary constraints and notions of accounting profit centers. In case the company has to yield and renegotiate or grant discounts, then the total profit will be reduced, other things being equal, but again the brunt of the squeeze will be felt by the transportation activity, which will have to justify its existence. So in either case, whether the delivered prices reflect the low transportation rates or not, the small oil companies that do not own their own vessels and usually depend on the spot market tend to benefit much more from low rates than do the rest, and this, of course, does not please the large integrated firms.

In general, it will be to the advantage of the large oil companies (in terms of profits and competition) to shield the delivered and posted prices from the fluctuations of the spot tankship market. In the absence of any restraining force, such fluctuations, due to spot rate movements, will occur because of differences in the transportation intensity of the various crudes and products intended for a given market. If price adjustments are not made, there will be more than one price for the same homogeneous product in the same market, a factor which will influence the buyers to move en masse from one supplier to another. The relative rigidity of the posted prices

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There is another reason for the rigidity of posted prices. The U. S. depletion allowance of 27 1/2% is based on actual revenues from production.
implies that the emphasis is placed on delivered prices, although no such prices are officially quoted. The emphasis on delivered prices is very logical, nevertheless, because it guarantees price equalization at the consumer markets.

Unless the producer has some control over transportation, he cannot very well exercise control over delivered prices nor, consequently, over rates of production. Such uncertainty is very costly and, in order to eliminate it, the oil companies may attempt to increase their tonnage in the hope of reducing their dependence on chartered vessels. The irony is that the oil companies do not realize that their own behavior is instrumental in determining the market outcome, and they react in a manner that prolongs the depression in the tankship markets and aggravates future cycles.¹

The consequence of the Suez Canal frenzy may be seen in the comparison of the tonnage owned with the tonnage under construction shown in Tables 1 and 3 respectively. The aforementioned comparisons show that on January 1, 1959, among the oil companies, the nine largest owners of tankers had vessels on order and under construction equal to 80% of their total ownership of that date, while the comparable figure for the independents--listed by name in Tables 1 and 3--was only 35%. What part of this discrepancy, of course, may be the consequence of faster reaction of the independents, who may have ordered and received most of their vessels before the oil companies placed their orders, we do not know exactly, but we can safely infer that it is not very significant. During the Suez Canal crisis and

¹This paragraph refers to individual action and not to any co-operative action among the oil companies.
the two years immediately following, the lead time from order to delivery was over 22 months. Consequently, not many orders initiated by the crisis could have been delivered by December 31, 1958, even under the hypothesis that the independents react faster.

Tables 4, 5, and 6 provide ample evidence that on January 1, 1957 the oil companies owned 36% of the total number of vessels, but only 35.1% of the total carrying capacity. The corresponding figures for the independent fleet were 60.7% and 62.5%, showing that the race toward larger vessels was started by the independents. By January 1, 1959, the difference in percentages of ownership became greater, showing that the independents were the first to place orders. The latter observation is substantiated by Table 5, which shows that the share of the oil companies in the backlog of orders has increased steadily and significantly, while that of the independents has followed the opposite trend. This trend, which occurred after the drop in rates, is consistent with our hypothesis that the oil companies follow the independents, but by the time the consequences of their reactions are manifested they will be in vain attempting to assert their independence from the tanker market during periods of low rates. We further notice in Table 5 that the vessels ordered by the oil companies were larger. Of the total number of vessels under construction on January 1, 1957, 27.7% belonged to oil companies and 72.3% to independents. In terms of carrying capacity, however, the share of the oil companies was 31.7% and that of the independents 68.3%. By December 31, 1958, 33.5% of all vessels under construction, representing 38.4% of total carrying capacity were for the oil companies, and 63.7% for 60% of carrying capacity were for the independents. As shown previously in Table 3 on December 31, 1958, the average size of the company vessels under construction at that time was 20,600 DWT., versus 33,700 DWT. for the independents.
| OWNERSHIP | TOTAL | 6,000/15,000 | 15,001/20,000 | 20,001/30,000 | 30,001/40,000 | 40,001/50,000 | 50,001/60,000 | 60,001/70,000 | 70,001/80,000 | 80,001/90,000 | 90,001/100,000 | 100,001/150,000 | 150,001/200,000 | 200,001/250,000 | 250,001/300,000 | 300,001/400,000 | 400,001/500,000 | 500,001/600,000 | 600,001/700,000 | 700,001/800,000 | 800,001/900,000 | 900,001/1000,000 |
|-----------|-------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| OIL COMPANIES | | | | | | | | | | | | | | | | | | | | | | | |
| Jersey | 53 | 158.0 | 43,790 | | | | | | | | | | | | | | | | | | | |
| Standard-Vacuum | 14 | 3.6 | 29,390 | | | | | | | | | | | | | | | | | | | |
| Total | 57 | 161.6 | 63,170 | | | | | | | | | | | | | | | | | | | |
| Allied/Anchland | | | | | | | | | | | | | | | | | | | | | | | |
| Atlantic Refining | 57 | 141.1 | 36,840 | | | | | | | | | | | | | | | | | | | |
| British Petroleum | 13 | 37.3 | 42,090 | | | | | | | | | | | | | | | | | | | |
| Cities Service | 5 | 1.0 | 65,000 | | | | | | | | | | | | | | | | | | | |
| Continental Oil | 23 | 61.1 | 38,800 | | | | | | | | | | | | | | | | | | | |
| Gulf | 45 | 101.4 | 33,760 | | | | | | | | | | | | | | | | | | | |
| Hess | 5 | 2.1 | 41,860 | | | | | | | | | | | | | | | | | | | |
| Superior | 3 | 6.5 | 32,270 | | | | | | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | | | | | | | | | | |
| INDEPENDENT COMPANIES | | | | | | | | | | | | | | | | | | | | | | | |
| Andrew | | | | | | | | | | | | | | | | | | | | | | | |
| Barber Oil | 5 | 18.8 | 46,000 | | | | | | | | | | | | | | | | | | | |
| Caracas | 10 | 27.5 | 40,990 | | | | | | | | | | | | | | | | | | | |
| Kemmler, Joshua | | | | | | | | | | | | | | | | | | | | | | | |
| Kukovina | 3 | 4.8 | 23,970 | | | | | | | | | | | | | | | | | | | |
| Kurz | 4 | 11.1 | 45,370 | | | | | | | | | | | | | | | | | | | |
| Lewis | | | | | | | | | | | | | | | | | | | | | | | |
| Livans | 5 | 10.9 | 31,780 | | | | | | | | | | | | | | | | | | | |
| National Bulk | 3 | 21.0 | 106,520 | | | | | | | | | | | | | | | | | | | |
| Marchas | 7 | 26.5 | 55,790 | | | | | | | | | | | | | | | | | | | |
| Micolou | | | | | | | | | | | | | | | | | | | | | | | |
| Nomikos | | | | | | | | | | | | | | | | | | | | | | | |
| Onassis | 14 | 53.7 | 56,640 | | | | | | | | | | | | | | | | | | | |
| Verginis | 2 | 4.9 | 36,650 | | | | | | | | | | | | | | | | | | | |
| Wang | | | | | | | | | | | | | | | | | | | | | | | |
| Other Independent Companies | 659 | 971.3 | 31,770 | | | | | | | | | | | | | | | | | | | |
| TOTAL INDEPENDENT COMPANIES | 516 | 1,122.1 | 33,700 | | | | | | | | | | | | | | | | | | | |
| GOVERNMENT COMMERCIAL | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL WORLD COMMERCIAL | 810 | 1,935.1 | 35,600 | | | | | | | | | | | | | | | | | | | |
| MAJOR BONUS TOTALS | | | | | | | | | | | | | | | | | | | | | | | |
| Included Alone | 35 | 249.5 | 30,080 | | | | | | | | | | | | | | | | | | | |
| Independent Norwegian Owners | 149 | 249.5 | 30,080 | | | | | | | | | | | | | | | | | | | |
| Independent Greek Owners | 55 | 160.7 | 42,200 | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
## Table 4

**Ownership of Vessels of 6,000 DWT. and Over**

<table>
<thead>
<tr>
<th>Date</th>
<th>Oil Companies</th>
<th>Independents</th>
<th>Government</th>
</tr>
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<td>1</td>
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<tr>
<td>January 1, 1957</td>
<td>36.0</td>
<td>60.7</td>
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<tr>
<td>% of Total Vessels</td>
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<td>61.2</td>
<td>3.2</td>
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<td>% of Total Capacity</td>
<td>35.0</td>
<td>61.9</td>
<td>3.1</td>
</tr>
<tr>
<td>July 1, 1958</td>
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<tr>
<td>% of Total Vessels</td>
<td>33.5</td>
<td>63.4</td>
<td>3.1</td>
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<tr>
<td>% of Total Capacity</td>
<td>33.5</td>
<td>63.4</td>
<td>3.1</td>
</tr>
</tbody>
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**Source of Data:** Transportation Co-ordination Department, Standard Oil Company, New Jersey
<table>
<thead>
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<th></th>
<th>Oil Companies</th>
<th>Independents</th>
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</thead>
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<tr>
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<td></td>
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<tr>
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<tr>
<td><strong>July 1, 1957</strong></td>
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<tr>
<td>% of Total Vessels</td>
<td>29.8</td>
<td>70.2</td>
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<tr>
<td>% of Total Capacity</td>
<td>35.2</td>
<td>64.8</td>
<td>0</td>
</tr>
<tr>
<td><strong>January 1, 1958</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>29.1</td>
<td>68.1</td>
<td>2.8</td>
</tr>
<tr>
<td>% of Total Capacity</td>
<td>34.2</td>
<td>62.9</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>July 1, 1958</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>32.4</td>
<td>64.3</td>
<td>3.3</td>
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<tr>
<td>% of Total Capacity</td>
<td>37.6</td>
<td>59.7</td>
<td>2.7</td>
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<tr>
<td><strong>January 1, 1959</strong></td>
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<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>33.5</td>
<td>63.7</td>
<td>2.8</td>
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<tr>
<td>% of Total Capacity</td>
<td>38.4</td>
<td>60.0</td>
<td>1.6</td>
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Source of Data: Transportation Co-ordination Department, Standard Oil Company, New Jersey.
TABLE 6

Total Tonnage Including New Construction
Vessels of 6,000 DWT. and Over

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<tr>
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<th>Governments</th>
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</tr>
<tr>
<td>January 1, 1957</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>33.6</td>
<td>64.1</td>
<td>2.3</td>
<td>33.6</td>
<td>65.1</td>
<td>1.3</td>
</tr>
<tr>
<td>% of Total Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 1, 1957</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>33.7</td>
<td>64.1</td>
<td>2.2</td>
<td>34.8</td>
<td>64.1</td>
<td>1.1</td>
</tr>
<tr>
<td>% of Total Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 1, 1958</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>33.2</td>
<td>63.8</td>
<td>3.1</td>
<td>34.1</td>
<td>63.4</td>
<td>2.5</td>
</tr>
<tr>
<td>% of Total Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 1, 1958</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>33.6</td>
<td>63.2</td>
<td>3.2</td>
<td>35.0</td>
<td>62.8</td>
<td>2.3</td>
</tr>
<tr>
<td>% of Total Capacity</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>January 1, 1959</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Vessels</td>
<td>33.4</td>
<td>63.2</td>
<td>3.4</td>
<td>34.9</td>
<td>63.2</td>
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<tr>
<td>% of Total Capacity</td>
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</tr>
</tbody>
</table>

Source of Data: Transportation Co-ordination Department, Standard Oil Company, New Jersey
The combined figures of existing tonnage and new construction are presented in Table 6; they reveal that the oil companies have increased their share of ownership slightly in the post Suez period, which again may serve to substantiate our assertion concerning the behavior of oil companies during periods of low rates and tonnage surpluses. Although the oil companies may follow in terms of reaction time behind the independents yet they are not outdone.

We feel that the institutional constraints will not appreciably affect the otherwise great number of orders generated by price-elastic expectations during periods of high rates, but will probably combine with retirements to cause the lower part of the demand schedule to assume a greater elasticity than otherwise.\(^1\) The reasons for such an effect are the disproportionality of age and size distribution within the industry—namely, an intra-industry mismatch of existing surpluses and needs for new tankers for replacement purposes—and the role that the oil companies play. The oil companies, as we have argued, will probably assert their independence from market fluctuations exactly at the time when surpluses exist for the industry as a whole. We have also pointed out that, given the existence of economies of scale in tankship building, and tankship operation, orders placed are by nature surplus producing. Ancillary technologies (harbor facilities, refineries, storage etc.) continuously advance, and markets keep on growing, thus allowing the utilization of larger and larger vessels. Consequently, because of size indivisibilities, replacements introduce more capacity than that lost to retirements. Finally to the extent that the somewhat asymmetric

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\(^1\)This may be shown as an oscillation because the impact may be discontinuous.
behavior of the oil companies during low rates combines to produce a uniform impact, it is expected to be disequilibrating. In magnitude, however, the orders initiated by institutional considerations are minor relative to those placed when rates are high; one may say that they are only of an adjusting nature, bringing the ratio of owned versus chartered capacity to the "desired" equilibrium. Because the independents, in general, react faster to changes in rates, their orders disturb the desirable ratio of ownership of the major oil companies. Consequently, the big companies may place orders later--when spot rates are low and after the independents withdraw from the shipbuilding market--in order to restore this presumptive equilibrium. Although these orders which are placed under conditions of excess transportation capacity may be disequilibrating in the short run and intermediate run, under conditions of cyclical demand they may be long-run equilibrating.

The number of tankers under construction may be also influenced by the domestic policies of various countries. Some governments consider it a national pride to have vessels flying their flag, while others may attempt

\[1\] Often the oil companies do not react in time not because they do not want to do so, but because of their inflexible organization structures. As an illustration of what may happen consider the following actual case. During the Suez crisis, the tanker department of a major oil company requested in its budget funds for new vessels. The request went through the proper channels and was returned for "more details." The details were furnished and after study the finance committee approved the appropriation initially. This meant that negotiations with shipyards were approved but actual authorization for fund expenditure would await another application at the time the contract was to be signed. Orders were placed, but by this time rates had fallen. Consequently, in the authorization, funds were cut, and some orders had to be cancelled. The whole process took approximately twelve months. Such a delay between decision and action is not evident with the independents.

\[2\] Notice that this statement refers to tanker rates not shipbuilding costs. The latter may still be high or even at their peak since shipbuilding costs seem to lag a few months behind spot rates.
through legislation to encourage shipbuilding activities in their countries. Presumably, such efforts by governments are intensified during periods of depressed market conditions and excess shipbuilding capacity. The actual contribution of these pressures to the number of orders placed is not known, but it can be safely assumed that it is relatively insignificant. In the United States, where several attempts have been made in the past to aid the shipbuilding industry,¹ such programs did not materially affect the orders for tankers. It is still more attractive to own and operate a vessel under a foreign flag even though the owner must forego the benefits that accrue to the United States flag vessels operated under the various maritime acts.

A study of the shipbuilding statistics shows that the backlog of orders outstanding in the United States lags behind the cycle of spot rates by approximately one year, indicating that orders are determined by rates.² Quantitatively, during 1955-1959, the tankship orders placed with United States yards have fluctuated between 1.6% and 8.1% of the world total, which shows that any legislative effect on orders, however important it may be for the domestic industry, is not expected to affect the world total in any significant manner.


²This lag is due to several factors: (a) Protracted negotiations take place before the signing of a contract. So the initiation of an order and the award do not occur at the same point of time. (b) Construction statistics usually appear when construction orders are signed. Between the award of the contract and the construction authorization there may be a time lag due to administrative red tape and details. (c) The fact that foreign yards are approached first, since they are less expensive.
E. Spot Rates, Shipbuilding Costs and Orders Placed--Empirical Observations

A strict empirical test of the validity of our theoretical formulation is impossible because of the lack of adequate data. Information on spot rates and orders placed has been accumulated, and all the details of changes in their magnitudes are known, but the available information on shipbuilding cost is sketchy and rather unreliable. Because the contract price is considered confidential information, it has been impossible to put together a reliable and continuous time series index of the cost of shipbuilding in order to quantify monthly changes. Furthermore, each contract contains its own particularities. As a result, and even if the agreed price of contracts were known on the basis of the contractual provisions, extensive and complicated calculations would be necessary before all contracts are brought down to a homogeneous basis. Therefore, indirect approaches must be used in deriving an index for shipbuilding costs and the demand schedule for new vessels.

Figure 9 demonstrates the existence of a close relationship between orders placed and spot rates, the correlation being much greater during the 1954-1958 cycle. With proper adjustment to eliminate known impurities the similarities between the two time series become even more striking. Let us take for example the "unexplained" influx in orders during August and September of 1957. An analysis of some contracts which were placed by oil companies in August-September of 1957, showed beyond doubt that the majority of orders analyzed were initiated (and often concluded but not announced) in January-March of 1957. As the spot rates started falling, the oil companies started protracting the negotiations and putting demands for concessions.

In one case an order for four supertankers of 40-45 thousand DWT each, was placed in February 1957 with Italian yards at $275 per DWT, but was not
announced. In September of 1957 an announcement was made that this company placed an order for five supertankers of 40-45 thousand DWT each. What actually happened was that the Italian shipyard, not wishing to lose a good customer, finally offered to build five vessels instead of four for the total price originally agreed upon. So the net result was that the oil company got a free vessel, (effectively the cost per DWT. came down to $225), the February transaction became a statistic in September, the backlog of the Italian yard increased, but the shipbuilder did not get any additional revenue.

The relationships shown in Figure 9 and the qualitative detail behind the empirical observations provide strong support for the assumption that the spot-rate expectations of the users of tankship services are elastic, and the belief that the magnitude of the initial shock determines the swiftness of the response and the magnitude of the fluctuations. The fact that the Suez Canal crisis affected a greater percentage of the tankship capacity than the Korean War may explain the quantitative difference between the two cycles. Of course, the value of the elasticity index is not always the same, depending upon the point of measurement on the expectations schedule.

Let us recapitulate briefly our arguments concerning the demand and supply schedules for tankships and relate these arguments to available qualitative empirical evidence as a preparatory step to the discussion of the next section on the quantitative relationship between spot rates and orders.

---

1 The notion of elasticity of expectations applies to changes from "what prices would have been" and has nothing to do with the level of magnitudes. Namely, if we say that expectations are elastic at a point and \((\partial P_f / \partial P_o) (P_o / P_f) > 1\), we have no reason to deduce that \(P_f > P_o\). Also, when we make a statement concerning price elasticity of expectations, it applies to all prices in the future for all \(t > 0\).
At the beginning of a rate movement, the expectations of the users of tankers seem to be inelastic because the users are reluctant to believe in the permanency of such movement, especially if the rates have been at a constant level for a relatively long time. Users seem to feel that such movement is a temporary deviation from an equilibrium level which necessitates vigilance rather than action. As the rate movement gains momentum, however, their expectations become more and more elastic, until, finally, a level is reached beyond which logic tells them that rates cannot be expected to rise in the long run. In between this final turning point and the original equilibrium, there may be some pause for reflection, and withdrawal from the market but it does not usually last long. Although such pause, incidentally, will change the slope of the effective demand schedule from positive to negative and then back again to positive, it does not necessarily imply that expectations also changed temporarily from elastic to inelastic and then back to elastic again.

Implicit in such a spot-rate elasticity of expectations is the belief that not only is the present cause of the shift in demand for tankship services real but manifestations in the future will be even greater. Therefore, the logical reaction of the owners of tankship services is to place more orders with shipbuilders, thus causing shifts in the shipbuilding schedules.

As a result of such shifts in the shipbuilding schedules we expect to observe a secondary reaction pattern molded by changes in shipbuilding costs. Even though the pattern of behavior in the tankship building markets is not
believed to be as elastic as the spot-rate expectations schedule, it is expected to enhance the shifts in the demand for vessels and to possess all the qualitative attributes of the spot-rate schedule of expectations. As soon as prices per DWT. start their upward trend, the shipbuilders rush to accept orders and, in general, become very accommodating. They promise early delivery, omit escalation clauses (that is, quote fixed prices), grant liberal credit terms, and so on. This situation, however, does not last long; soon the shipbuilders play "hard to get" and assume the upper hand with demands for the total payment even before delivery, escalation clauses, and five-to-six-year delivery schedules. At the same time, instead of devoting all their capacity to shipbuilding, they start employing part of their organization efforts to expansion, thus cutting their current capacity somewhat for the purpose of building future capacity.

It is unlikely that the observed behavior of the shipbuilders is due to real reasons rather than expectations. It seems that they start with inelastic expectations, which become more and more elastic as the price per DWT. is bid up. Evidence shows that at first they postpone expansion and devote all their capacity to the construction of ships, but after they fill their order books for four or five years to come, (something which does not take long to achieve given the reactions of those operating in

---

1 What we wish to say here, is that expectations in the tankship building market are elastic, but the coefficient of tankship transportation may not be as great as the one operating in the tankship transportation market.

2 See Jacobs, John I., World Tanker Fleet Review, 31st December 1957; p. 6; and also issues of 30th June 1956, p. 4; and 31st December 1958, p. 6.

3 The notion of cutting output for the sake of expansion is the essence of Professor W. W. Rostow's early business cycle explanations in economic history. Traces of this thinking are found in his British Economy in the Nineteenth Century, Oxford, 1948 and Gayer, Rostow, Schwartz, The Growth and Fluctuation of the British Economy 1790-1850, 2 Volumes, Oxford, 1953.
these markets) their expectations become elastic and they switch some of their efforts to expansion. In addition, the shipbuilders raise demands for better and better terms. Some of them, even set the promised delivery date far enough in the future to allow themselves leeway for the expected "prize contracts."

For example, Table 7 shows that the Japanese yards have a yearly capacity of at least 140 T-2 equivalents; yet in late 1956 and very early in 1957 these yards were quoting deliveries beyond 1962. A glance at Table 8 shows that beyond 1960 the years for Japan are very lean indeed, which explains why the Japanese yards were the first to show signs of weakness. Yet to repeat again, they were refusing in late 1956 and early 1957 orders for delivery prior to 1962. This type of behavior cannot be explained satisfactorily, unless we assume elastic expectations. The total backlog of orders with Japanese yards on December 1958 was less than 2 1/2 years of activity.

Although the expectations schedules of buyers and sellers may be somewhat out of face, yet we believe that there is a parallelism in the observable behavior between the two sides of the market. Prices, however, are neither explosive nor are they perpetually establishing new lows, for reasons that we have already expounded when we analyzed the patterns of behavior operating in the tankship transportation markets. As the current cost of shipbuilding rises, the users of vessels move on an elastic expect-

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1 For more discussion on the theoretical issues of expectations, see Baumol, Economic Dynamics, pp. 83-115; Hicks, Value and Capital pp. 250-251.
2 Really, they were even reluctant to accept orders according to reliable sources. To contrast this situation with what happened later see Westinform Shipping Report, No. 129, 1959, pp. 2-6.
3 According to the New York Times of Sunday, March 22, 1959, page 16S, "Shipyards all over the world were reported as quoting fixed prices again. In recent years shipyards have insisted on escalation clauses in contracts."
TABLE 7

Deliveries in the Period - 12 Months Ending:

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<tbody>
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<td><strong>Total</strong></td>
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<td><strong>339.5</strong></td>
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</table>

Figures expressed in T-2 equivalents.

Source: Transportation Co-ordination Department, Standard Oil Company, New Jersey
### TABLE 8

<table>
<thead>
<tr>
<th>Country of Building</th>
<th>Under Const. as of 1/1/59</th>
<th>1959</th>
<th>1960</th>
<th>1961</th>
<th>1962</th>
<th>1963 and Beyond</th>
<th>Total Backlog of New Construction as of 1/1/59</th>
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<td><strong>209.4</strong></td>
<td><strong>231.4</strong></td>
<td><strong>1,912.4</strong></td>
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</tbody>
</table>

All figures in T-2 equivalents

Source: Transportation Co-ordination Department, Standard Oil Company, New Jersey
tations schedule, causing compounding shifts in the demand schedules facing the owners. The process gains momentum up to a point as we move in a northeasterly direction. These shifts do not bring about a balance in supply and demand, but instead, are disequilibrating, forcing prices to very precarious levels. Finally, the budget effects force the buyers to withdraw from the market and may also influence the expectations of the users of vessels to become inelastic. This latter change, however, is not necessary, since withdrawal is otherwise guaranteed.

The price in the meantime may have reached a lofty yet shaky temporary equilibrium (on that part of the supply schedule that bends backwards) when suddenly not only the demand schedules may show signs of shifting to the left (because the users withdraw from the market as a consequence of the budget effect and possibly a change in their expectations), but also the supply schedules start shifting to the right as the new capacity added in response to the elastic expectations of the owners becomes operational. It does not take long for the price to reach its peak, but it takes even less time for it to reach the bottom.

Violent fluctuations of this sort are typical of the tankship markets. We shall return to them later (to show their adjustment paths) when we discuss the formation of short-term (spot) charter rates.

F. Spot Rates and Orders Placed—Quantitative Evidence

In order to give operational content to the theoretical relationships governing orders for new vessels, we need to have, among other data, monthly time series of shipbuilding costs. The latter type of information is not available not only because it is often considered proprietary, but also
because transactions for tankship building do not occur continuously. Furthermore, as we already stressed, there is often a time lag of a few months between the initiation of a contract and the announcement of the award (if it is announced and its terms made public).

In looking for a substitute for shipbuilding costs, we naturally focused our attention on tanker rates. Intuitively we can justify the choice because tanker rates induce expectations which affect orders and shipbuilding costs. We have, however, a more objective reason for such choice. On the basis of statistical relationships that we derived between changes in spot rates and changes in the Fairplay\(^1\) index for the cost of a new vessel if it were in stock, the movements in short-term rates can explain 86.5% of all changes in shipbuilding cost. Consequently, we decided to approximate the value of our function by deriving a relationship between tanker rates and orders placed.

Figures 10 and 11 present scatter diagrams of monthly spot rates per 1000 ton-miles versus monthly orders placed for the periods 1949-1953 and 1954-1958, respectively. Examining first Figure 10, we notice that for the total range of rates the correlation between orders placed and spot rates appears to be positive. Such a relationship, however, is not uniform. If we connect the monthly movements in rates\(^2\) and orders placed, especially for 1951 and 1952, we find that these movements describe "loops" as if moving on the periphery of a crude figure of eight. This is consistent with our hypothesis that spot rate expectations are elastic and that the whole demand

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\(^{1}\) Fairplay is a London nautical publication which provides twice a year an index for vessel costs (a) for a new vessel if it were ready and (b) for a vessel if ordered.

\(^{2}\) The readers may remember that these years include the Korean War. The movements in rates were caused by temporary tonnage shortages and the expectations created by the conflict. Our notation gives the month and the year for each observation.
schedule exhibiting the impact of interperiod substitutions shifts to create the multiple loops. Any reversal in the direction of the demand schedule between the region of static relevance and the upper bound, may be caused, as we have already explained, by temporary withdrawals for reappraisals, temporary changes in expectations, purely stochastic reasons, failure of our measurement system to record unsatisfied demand.

Of the above mentioned factors the first two are interrelated, and "purely stochastic reasons" as the motivating force behind the changes must be discounted, because of the regularity of the turning points of the schedules shown in Figures 10 and 11. There is no doubt that our observations may have failed to record the full impact of price-elastic expectations especially within the price regions over which there exists symmetry in the expectations of buyers and sellers. Although the operations in the tankship building markets are flexible enough (with supply stretching to meet demand) to mitigate the impact of such occurrences, yet they may not completely eliminate it. We have already noticed how the Japanese shipbuilders discouraged orders by quoting protracted deliveries (over six years). If a backward bending supply (before it shifts far enough to the right) is influencing our observations, then what appear to be "temporary withdrawals for reappraisals" and "temporary changes in expectations" are nothing more than consequences of the deficiencies in our measurement methods. It appears to us after extensive analysis that this last observation offers the most plausible explanation. Note, however, that in no way the hypothesis that price-elastic expectations are present is impaired.

The lower part of the exhibit shows that there may be turning points in expectation at about $1.30-$1.40 per 1,000 ton-miles, at $2.80 and, finally,
at $4.20. As we will see later, a rate of $1.30-$1.40 per 1,000 ton-miles is remunerative for most ocean tankers, especially for vessels of T-2 size and over, and thus may lie at the boundary of the region of strict static relevance. This fact may indicate that the lower part of the exhibit chiefly shows the impact of static considerations, with dynamic expectations prevailing elsewhere.

When we were discussing the theoretical relationships developed earlier in this chapter, we mentioned that at very low rates, because of the opposing effects of expectations on orders (substitution versus income effects) and the scrapping-replacement programs, we should not be surprised to find what we then called some "schizophrenic" tendencies in our schedules. This is clearly shown in Figure 10, which offers further evidence of the validity of our formulations.

What appears to be a turning point in expectations at 2.80 may only be the result of what we previously called deficiencies in measurement methods. Otherwise we cannot explain such an abrupt (as well as regular as Figure 10 shows) change in expectations, from elastic to inelastic and then back to elastic, unless we assume that the operatives have no memory at all and every time prices move away from an equilibrium (stable or unstable) a new set of elastic expectations is created. Finally the uppermost turn at $4.20 is no doubt due to the budget effect that we have previously explained in detail.

Turning now to Figure 11, we notice that what we have just observed concerning the years 1949-1953 also applies to the period 1954-1958. It is interesting in this conjunction to trace the rate movements in 1956 and 1957 and compare them with those of 1951 and 1952. The qualitative similarities
are indeed amazing, both in terms of the general shape and also swiftness of movements. Without the presence of price-elastic expectations, such similarities would be very improbable. Furthermore, no one would expect under static conditions to observe a seven-fold change in prices and orders placed in the short period of a few months.

The impact of expectations and the result of replacement programs were much more pronounced during the 1954-1958 period, as shown by the four-fold increase in the range of orders placed. As seen in Table 2, the age distribution of tankers is skewed because of the war-built vessels; hence, the replacement programs will be extensively influenced by such skewness.

Rate expectations during the Suez crisis appear to have taken the market through a complete cycle in a short period of six months, thus causing orders to trace a big loop. At low rates, the opposing effects of expectations (cancellations versus budget effects) and the replacement programs define the end points of a range of approximately 340 T-2's, from plus 200 to minus 142. Within this amazingly large range, smaller fluctuations (oscillations) are observed, all, incidentally, with rates between 60 and 70 cents per 1,000 ton-miles.

Even though qualitatively the pattern of orders placed, with respect to changes in the level of spot rates, is the same for both five-year periods, we notice some quantitative dissimilarities. In addition to the already observed greater range of movement of orders placed, as influenced by the spot-rate elasticities of expectations and the replacement programs, we also notice the following.
1. The lowest point reached by the spot rates during the 1949-1953 period was about 75 cents per 1,000 ton-miles versus 58 cents for the 1954-1958 period.

2. The critical turning point of expectations at low levels seems to be $1.30-$1.40 versus about $1.10-$1.20 for the two time periods respectively.

3. The highest level reached by spot rates during the 1949-1953 period was $4.30 per 1,000 ton-miles as compared to $4.49 for the 1954-1958 period.

These quantitative dissimilarities can all be explained in terms of the changes in the size composition of the tankship fleet. As we will see later, because of economies of scale in tankship building and tankship operation, the newer larger vessels can operate at a lower cost. Consequently, any replacement of marginal vessels will bring about a drop in the cost curves of the industry. During the 1948-1953 cycle the marginal vessel was 12,000 DWT. The influx of orders generated in 1951 and 1952 and the subsequent retirement of obsolete vessels, made the T-2, a vessel of 16,500 DWT., the marginal vessel during 1954-1958.

The out-of-pocket cost of the marginal vessel during 1948-1953 was approximately 77 cents per 1,000 ton-miles of oil carried (or U.S.M.C. minus 50%), and that of a T-2 was 61 cents (or U.S.M.C. minus 60%). Rates, however, can go below out-of-pocket cost, because of the alternative costs of keeping the vessel idle. Consequently, a difference around 16 cents per 1,000 ton-miles in the refusal rate, should be expected.

The same thing can be said about the upper bound of the region of strict static relevance, which appears to be between $1.30-$1.40 versus $1.10-$1.20 in the respective two cases. Since the idea of a "fair rate" (including a
fair return on investment) for the vessels operating at any moment of time is a static notion, behavior should be influenced by current cost considerations in static terms\(^1\) unless dynamic expectations enter into play. In our case, the turning points are between $1.30-$1.40 versus $1.10-$1.20 for the respective time periods, the discrepancy we feel being due to the average full-cost differentials of the vessels operating during the two time periods under consideration.

At first glance it may appear that the highest levels reached by spot rates during the two cycles are inconsistent without previous findings and arguments. Actually this is not the case, and the results are very consistent if we examine the role of uncertainty in planning. The larger the vessel, other things equal, the greater the risk of underutilization. Consequently, during periods of great uncertainty (low rates), all the benefits of economies of scale are conceded to the charterer as an inducement. When rates are high, however, and especially with price-elastic expectations, there is no uncertainty in the mind of any one concerning the full utilization. If anything, the charterers feel uncertain as to whether they will find enough vessels to satisfy their magnified needs. As a result the efficient tankers will command a premium equivalent to their operating cost efficiency, if risks of underutilization are absent and all other conditions are assumed to be identical.

If what we have just observed is valid, namely that at low rates the influences on orders placed are the result of static cost effects, and the

\(^1\)This should be particularly true in our case because the oil companies, who are the "buyers" of tankship services, operate their own fleets and thus know the cost functions of their suppliers.
budget-replacement activities, one would expect to find a negative over all correlation between rates and orders outstanding at low rates, but a positive correlation at high rates. Table 9 gives us an indication that this is what we do find. We notice that the zero order correlation coefficients are all negative and that some of them are very significant for periods of low rates, particularly for the coefficients of correlation of rates with changes in orders placed. The logarithmic derivation is even more significant, which indicates that behavior in the tankship markets may be conditioned much more by rates of change in the relevant parameters than by absolute levels.

When rates are high the respective correlation coefficients are not as significant as when rates are low, with the exception of the correlation between the index of expectations and orders outstanding (non logarithmic relation). The direction of the relationships, however, is positive, with the exception of the correlation between the index of expectations and the changes in orders placed. Knowing that the correlation between the index and orders outstanding is positive and fairly significant, the negative correlation between the index and the changes in orders placed may indicate the existence of measurement impurities. The index is developed under the assumption that expectations are influenced by distributed lags. So it is a "smoothed out" short-term rate. In contrast, the changes in orders placed are very volatile. Furthermore, the date of record, as we have already explained, may not coincide with the date of initiation of the

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1These are partial correlation coefficients of the first order and were obtained as part of the multiple regression and correlation 704 program that will be discussed later.
TABLE 9

**Zero Order Correlation Coefficients**

**Rates vs. Orders**

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<th>Non Logarithmic</th>
<th>Lows</th>
<th>Highs</th>
<th>Both</th>
</tr>
</thead>
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<tr>
<td>Spot Rate Level vs. Orders Outstanding</td>
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<td>.2060</td>
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<td>Spot Rate Level vs. Changes in Orders Placed*</td>
<td>-.855</td>
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<td>-.291</td>
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<td>.03445</td>
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<td>Index of Expectations vs. Changes in Orders Placed</td>
<td>-.826</td>
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**Logarithmic Relation**

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<th>Lows</th>
<th>Highs</th>
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</thead>
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<td>.1154</td>
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<td>.4882</td>
</tr>
</tbody>
</table>

*The Changes in Orders Placed" are the percentage ratio of orders placed in period t (defined as a percentage of orders outstanding at the beginning of the period) over the respective magnitude of period t - 1.*

**The "Index of Expectations" is based on short-term rates and is derived in the chapter entitled "Model of Long-Term Rates." Briefly stated, this is a "weighted" index of rates prevailing over the previous four months.
contract, and during periods of high rates the amount of orders placed does not necessarily equal the quantity demanded (we suspect that it is smaller). The last qualification can explain the low correlation coefficients under high rates, which correlation coefficients nonetheless are positive with the exception of the one relating the index of expectations and changes in orders placed.

We cannot exclude the possibility that what we observed may be due to, or colored by real lags between impetus and manifestation of the impact. Such lags will particularly affect any relationships based on rates of change or differences, as contrasted with levels. Because events occur so fast, however, and the operatives do not allow examination of their minutes, it is very difficult to distinguish real from impure lags.

Evidences of lags real or otherwise may be detected in Figure 9, which presents a plot of the time series of spot rates and orders placed. Also lags are the cause of the difference between the correlation coefficients of "Spot Rate Level vs. Orders Outstanding" (.078) and "Index of Expectations vs. Orders Outstanding" (.6363).

In order to ascertain the existence of delayed reaction, we introduced lags into the monthly series for the total period 1949-1958, but the results proved somewhat disappointing. The only significant relationship—correlation of .7069 between orders placed and spot rates—was obtained when a three-month lag was introduced in the data.\(^1\) For this reason, instead

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\(^1\) If we look at Figure 9, we notice that the lags are not uniform, a possible indication that the elasticity of expectations depends on the previous point of temporary equilibrium. Namely, an alternating sequence of elastic, and, again, inelastic expectations may be repeated each time a deviation from a temporary equilibrium occurs.
of attempting to obtain improvements by experimenting further with shifts in the time series, it was decided to correlate quarterly rather than monthly data.

If our hypothesis about the average elasticity of orders with respect to rates is correct, the coefficients of regression and correlation between average quarterly rates and quarterly orders placed should be positive. The negative correlation that is believed to exist at low rates will be buried (if the data are not stratified) because it is valid for such a short range only approximately 40 cents out of 400.

Table 10 shows the quarterly data that were used to correlate the net orders placed with the corresponding rates for the years 1954-1958. During these years, incidentally, we have witnessed a complete cycle in rates and orders placed, and our observations, therefore, will not be disturbed by accidental stratifications.

The results of the correlation are quite encouraging. The regression equation explaining orders placed in T-2 equivalents is:

\[ Y = -55.75 + 1.36 \, X \]

where \( X \) represents the short-term rate in cents per 1,000 ton-miles. The correlation coefficient between \( X \) and \( Y \) is \( r = .88 \), and the coefficient of determination is .78, which is very satisfactory. The standard error of estimate is 98.33 T-2's, and the standard deviation 208.

\[ \text{Just to satisfy curiosity, five-month moving averages centered on the third month were attempted, but they gave no better results than those obtained with three-month lag. In multiple regression and correlation analyses, moving averages centered on the present time period impair the predictive value of the relationships. It is like inquiring what certain magnitudes will be \( X \) months from now in order to determine one value for the current period. If it is simple regression, however, and the smoothing is done only for the dependent variable, a relationship based on a moving average (if not centered at the terminal point) will aid prediction. It will, in effect, tell the behavior of the dependent variable that will satisfy the equation.} \]
### TABLE 10

World Tanker Construction Trends
Years 1948 to 1958
(6,000 DWT. and Over)

<table>
<thead>
<tr>
<th>Years</th>
<th>No.</th>
<th>T-2's</th>
<th>No.</th>
<th>T-2's</th>
<th>No.</th>
<th>T-2's</th>
<th>Avg. Rate Per 1,000 Ton Miles</th>
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</thead>
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<tr>
<td>1948</td>
<td>249</td>
<td>212.5</td>
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<td>71</td>
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We notice that the regression coefficient is positive and greater than one, and that the regression equation shows that only at low rates would we expect cancellations of orders. The point of zero orders of about 41 cents as given by the equation is not correct, because of the abrupt change at low levels and also because of the impact of the replacement programs that we have already explained.

In addition to the non logarithmic regression we attempted one of the form:

$$\log Y = a + bX$$

This was done in the hope of getting a better picture of the point of zero orders. The results are given in the following regression equation:

$$\log Y = 4.885 + 0.00527X$$

with a correlation coefficient of .7, a coefficient of determination of .5, and a standard error of estimate of .522. In order to avoid negative numbers, the dependent variable $Y$ in the above equation is defined as 200 plus actual orders placed in $T - 2$.

Obviously the semi-logarithmic correlation between orders placed and rates is not as good as the previous correlation. The coefficient of determination has dropped from .78 to only .5. The point of zero orders,\(^1\) however, occurs under the logarithmic formulation at 84 cents per 1,000 ton-miles, which is quite an improvement (as far as the empirical observations indicate) over the 41 cents per 1,000 ton-miles indicated by the linear formulation. As will be noticed in Figure 11, the upper limit of the rate range for negative net orders placed was at approximately $1.00 for the

\(^1\)When we refer to the point of zero orders, we imply zero net orders placed. Namely, orders placed minus cancellations equal zero.
1954-1958 period, and the lower limit at $.58. The value of $.84 given by the semi-logarithmic correlation is, therefore, in agreement with the observed range.

The scatter diagrams of the quarterly data of rates and orders placed for the two time periods 1949-1953 and 1954-1958 are presented in Figures 12 and 13. The observations that we made when examining the monthly data of Figures 10 and 11 appear to apply also in the case of the quarterly data.

Summarizing briefly the results of our qualitative and quantitative analysis, we can definitely say that the expectations of the buyers in both the tankship building and tankship chartering markets are generally price elastic. It may be difficult to understand such behavior, especially since statistics on orders outstanding are available to operatives and are "conservatively" dependable. One would think that the backlog of orders outstanding at any moment of time would be taken into consideration by the operative in shaping plans. Only under conditions of pure competition are the operatives ignorant of the interdependence of their action, and only complete naivete can explain absolute disregard of published data.

G. Charting versus Shipbuilding Revisited

Now that we have completed our discussion on both the chartering and the shipbuilding demand schedules, and have commented on their similarities, let us focus attention on a few of the differences that we have observed.

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¹ What we wish to state here is that these statistics may be understated due to lags. But even with lags, the backlog of orders outstanding is impressive.

² Even though we will be using for convenience the term "demand," we really refer to the locus of intermediate intertemporal equilibria of schedules that exhibit the impact of price elastic expectations.
**Figure 12**

<table>
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**Tons Miles (Quarterly 1949-1953)**

- 4.20
- 4.00
- 3.80
- 3.60
- 3.40
- 3.20
- 3.00
- 2.80
- 2.60
- 2.40
- 2.20
- 2.00
- 1.80
- 1.60
- 1.40
- 1.20
- 1.00
- 0.80

20 squares to the inch
Spot Rates and Orders Placed
1954-1958 Quarterly
Both schedules, as shown in Figures 6, 7 and Figures 10, 11, have the characteristics of the schedule presented in Figure 1. The demand for chartering, however, is proved to be more positively elastic. Its turning points are more pronounced, indicating that the rate elasticity of expectations is stronger in the tankship service market. There are very good reasons for the latter observation:

1. The breadth of the spot market is limited, and, consequently, conducive to wide rate fluctuations. What is more the market gets narrower as the rates rise. These relationships imply that any upward revision of aggregate transportation needs equal to, let us say, $C_a$ per cent of the total, will be manifested as

$$\Delta C_s = (T/S) \times C_a$$

where $\Delta C_s$ stands for the percentage increase in demand for vessels in the spot market, $T$ for total capacity and $S$ for the transportation capacity available in the spot market. Let us again point out that whether or not the demand is for long-term charters, as long as these are prompt, the charterers have to satisfy their needs out of the small capacity available in the spot market.

2. Unlike shipbuilding, the notion of capacity in the prompt spot market is very well defined. Of the long-term charter requirements, of course, only part is prompt, and the rest extended. For the extended part, admittedly, "short-chartering" suffices. That is to say, vessels that are being built or operating under charter can enter the sub-market of future employment at any time, and be chartered in the same way that new vessels which are not even on the drafting board are

---

1 For the reader who is not familiar with the industry, an explanation is due. Transactions are for either prompt or future delivery. Single voyage or spot charters are usually for prompt delivery; but time (or period) charters are usually for future delivery when rates are high, and prompt when rates are low.
contracted for extended deliveries. But there is nothing in the shipbuilding market that corresponds to the prompt chartering sub-market, since the shipbuilders do not keep inventory of completed or even semi-completed vessels. Furthermore, "buyers" know that it takes time to build a vessel. Consequently, the fact that their impatience is tempered by this realization allows for more flexibility in the shipbuilding capacity available at any moment of time.¹

3. With charters, because most of them are negotiated through brokers, the market is somewhat similar to other commodity exchanges and, as a result, the reaction to supply and demand considerations is very prompt. In shipbuilding, however, agreements are reached through private negotiations and the terms of contracts more often than not are kept secret, thus causing market imperfections. That is why there is plenty of information on charters—for anyone who wants to uncover it—but very little on actual shipbuilding costs. Given that cost information is very vital for the generation of price-elastic expectations, the attempts to shroud with secrecy the provisions of shipbuilding contracts tends to mitigate the impact of expectations.²

4. The administrative processes involved in chartering and shipbuilding are different. Chartering decisions are usually made at relatively low levels in the organizational hierarchy, while shipbuilding decisions have to go through the gamut of the capital budgeting process. As a result the reaction time in chartering is extensively shorter. The time delay which is

¹Conceivably the impatience function relating acquisition for future delivery, decreases exponentially with time, and as a result the marginal impatience for any period beyond the normal shipbuilding duration is very small.

²Conceivably secrecy may generate exaggerated rumors which may spread as "wild fire." That rumors exist in the tankship building markets there is no doubt. In fact often these are intentional. To the extent, however, that a lot of administrative red tape precedes the placement of contracts, enough time elapses to "cool off" somewhat the excited spirits.
introduced in shipbuilding serves comparatively, as a stabilizing factor, unless it happens to be equal to the time difference between two consecutive rate cycles. (The probability for such an occurrence is very small since elastic expectations generate enough surplus to create prolonged depressions.)

Another cause of time delays between impulse and response in shipbuilding is the amount of detail which has to be negotiated. In chartering, contractual provisions are so standardized that a telephone call (such as the one a person places with his stock broker) usually suffices. In shipbuilding, however, the contracts are very lengthy, legalistic and elaborate in detail.

Because of the above mentioned factors, the shifts in the demand schedules and the consequent fluctuations in rates are expected to be much more violent in chartering than in shipbuilding. Furthermore one would expect the shipbuilding time series to lag behind the chartering and spot-rate series.

The following may illustrate the differences in the fluctuations that are characteristic of the two markets. During the Suez Canal crisis in February 1957, spot rates reached a peak of over $4.50 per 1,000 ton-miles only to tumble down to 85 cents per 1,000 ton-miles in May 1957, and reach the bottom in November of the same year at about 62 cents. That is, in less than three months the rates dropped to less than 20% of their peak value and six months later to about 14% of the peak value. In contrast, shipbuilding prices reached their peak at the same time, but only by the end of 1957 did these show serious signs of weakness, and then mostly in Japan because of its excess capacity. The initial drop was about 25% of the peak value, and it was not until the latter part of 1958,

\[\text{See Jacobs, World Tanker Fleet Review, 31st December 1957, p. 6, also "Japanese Shipping and Shipbuilding," The Shipping World, March 26, 1958, pp. 329-330}\]
namely at least 18 months from the peak period, before the cost of shipbuilding reached approximately 50% of its peak value.\(^1\)

Possible differences in the elasticities of the lower part of the two demand schedules may betray further dissimilarities between tankship chartering and tankship building markets. As we have previously argued, in this price region the net income effect of own price changes is probably positive in the tankship service markets--because of the ownership and control of tankship capacity by the oil companies--but in the tankship building markets, there are two income effects and these oppose each other. In the latter case it is expected that the positive income effect will be stronger than the negative for the greatest part of the range of rates, except for the two extremities, where the negative income effect will probably be greater. This may explain the flatness of the top and the bottom part of the demand for new vessels, and also warn that--other things equal--slight differences may be observed in the levels of rates at which the two demand schedules change slopes.

The impact of the income effects may not be the sole reason, however, behind such differences in the levels of the turning points. Since the orders for new vessels are determined for the greatest part by tanker rates, the shipbuilding markets may lag a little behind.\(^2\)

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\(^1\)According to the Petroleum Press Service, September 1958, p. 326-329, and Jacobs, World Tanker Fleet Review, 31st December 1958, p. 6, the bottom price for 45,000-65,000 tonners was around $145 per DWT. during the last quarter of 1958, but The Shipping World of June 3, 1959, p. 543, reports that a "tough bargain" was obtained for a 47,000 DWT. vessel in Japan at $140 per DWT. in the second quarter of 1959. For smaller vessels the prices are higher, but the drop from the peak is of comparable magnitude.

\(^2\)Rates move so fast and so much when above the static long-run equilibrium level, this lag may not be significant in respect to time, but it could cause a rate level lag of turning points.
Finally, since the oil companies not only withdraw from the market at low rates but also enter into the spot market in order to relet\textsuperscript{1} their surpluses, the lower part of the demand schedule for charters will be more positively sloped than will that of shipbuilding. At "rock bottom" prices, both demand schedules may acquire negative slopes, but for different reasons. The slight increase in chartering activity at distress rates may be due to the entry of tankers into other trades--grain, molasses, etc.,--while, in the case of shipbuilding, the negative slope may be due to the income effect of own price changes, and the replacement--and readjustment--programs that we have explained previously.

\textbf{H. The Behavior of the Independents vs. That of the Oil Companies}

It has been previously argued that certain asymmetry of expectations between buyers and sellers is more typical than symmetry, although empirically expectations may be manifested as symmetric. Furthermore, evidence was presented suggesting that in shipbuilding the expectations of the sellers (shipbuilders), except at the very end of a price upswing, are rather price inelastic. If parallelism (symmetry of expectations) were applicable, we would expect those who use tankers as inputs (the independents and the oil companies) to postpone ordering ships to as late a future date as possible. This we found not to be the case, however, and the manner in which orders were placed in the past proved the expectations of the ship owners to be elastic.

The behavior of the ship owners is indeed amazing, not only because they choose to ignore published data on the backlog of orders, but also because

\textsuperscript{1}A "relet" is a sublet.
historically the cost of shipbuilding has tended not to remain at abnormally high levels longer than the average duration of ship construction. It appears, therefore, that the ship owners who place contracts with deliveries stretching beyond, let us say, two years are doubly naïve. But of course this is what creates the shipbuilding cycle.

Unfortunately, because of the confidential nature of shipbuilding contracts, there are no reliable consistent and continuous statistics of costs that make it possible to trace the changes from month to month and from year to year. We can form an idea of the relative fluctuations, however, by studying the export statistics of the Japanese Ministry of Commerce. The data presented in Table 11 indicate that the shipbuilding cost fluctuations may lag behind the rate fluctuations but, nevertheless, are following the same course. However amazing these cost fluctuations may appear, they do not tell the whole story. What we present in Table 11 is not actual cost data of orders placed during the respective years, but rather averages of historic contract prices for vessels delivered. The year to year fluctuations in the cost of order placed, therefore, must be much greater than what is shown here. Furthermore, averages

1 It seems that there is a tendency toward shorter average construction periods. Some yards today (1959) can deliver a ship in about one year. The Universe Apollo of 104,500 DWT. was delivered to the Universe Tankship Co. for chartering to Gulf Oil Co. in about 7 months by the Kure Shipbuilding Co. of Japan. In this case, however, the shipbuilding and tankship company both belonged to Ludwig's interests. This is a record time; the normal range is believed to be between 15 and 25 months.

2 The continuity of information is also affected by the way orders are placed. During periods of low rates, the "buyers" withdraw from the market in concert. Published data show that there was no single contract negotiated during the first half of 1959.


4 Because the data of Table 11 represent cost of delivered vessels, there is a lag of at least a year between the cost series and spot-rate time series.
TABLE 11

Average Price Per DWT.
Japan's Ship Exports 1949 to 1957

<table>
<thead>
<tr>
<th>Year of Delivery</th>
<th>Ave. Size (DWT.) Per Vessel Delivered</th>
<th>Ave. $/DWT. For Tankers Delivered*</th>
<th>Ave. Rate 1,000 Ton-Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>17,400</td>
<td>129</td>
<td>1.12</td>
</tr>
<tr>
<td>1950</td>
<td>4,200</td>
<td>159</td>
<td>1.52</td>
</tr>
<tr>
<td>1951</td>
<td>18,430</td>
<td>186</td>
<td>3.04</td>
</tr>
<tr>
<td>1952</td>
<td>20,560</td>
<td>202</td>
<td>2.35</td>
</tr>
<tr>
<td>1953</td>
<td>33,000</td>
<td>141</td>
<td>.94</td>
</tr>
<tr>
<td>1954</td>
<td>31,510</td>
<td>114</td>
<td>.89</td>
</tr>
<tr>
<td>1955</td>
<td>33,496</td>
<td>135</td>
<td>1.32</td>
</tr>
<tr>
<td>1956</td>
<td>35,432</td>
<td>174</td>
<td>2.44</td>
</tr>
<tr>
<td>1957</td>
<td>50,131</td>
<td>210</td>
<td>1.52</td>
</tr>
<tr>
<td>1958</td>
<td>185**</td>
<td></td>
<td>.68</td>
</tr>
<tr>
<td>1959</td>
<td>160**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>145**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Notice that these are not the average prices for ships contracted in that year. These are averages for the cost of ships delivered.

**Our estimates assume no disruptions like the Suez crisis or wars. The current (1959) contract prices for Japanese yards are approximately $145 per DWT. for supertankers of 45,000 tons. (J. I. Jacobs and Co. Ltd., World Tanker Fleet Review, p. 4.)

Source: Shipbuilding Data: AALL and Co. Ltd., Tokyo, Japan
Rates: Same as in Table 10
do not reveal the range of fluctuations, unless the data are uniformly stable. During the 1949-1959 period the cost of shipbuilding fluctuated between $120 and $300-$325 per DWT. These costs do not include contracts awarded with United States shipyards, which are always higher.

Policy-makers of various companies have been asked on several occasions why they rush at inopportune moments, and the answer always seems to be about the same. "When someone starts running, you start running after him. You run not because you want to, but because someone else started it. Things happen extremely fast; when you get into a stampede, you do not pause to ask questions. Our consolation is that our competitors are making the same mistakes as we do."

Both oil companies and independents are susceptible to this hysteria, as far as shipbuilding is concerned. The only difference is that the independents on the average lead the oil companies by about six months; otherwise they seem to be moving on a similar schedule of expectations. When we move to the area of chartering, however, where the two perform opposing functions, we notice that the symmetry no longer holds and the independents behave like sellers and the oil companies like buyers.

The independents, of course, may have more excuse for rushing into the shipbuilding market with orders than do the oil companies, because ships are used as inputs to their only final product, namely transportation services. In this respect there is no substitute. The oil companies, however, are in a more flexible position both in the short run and long run, and this should dictate

---

1Notice that this delayed response of the oil companies may be good or bad depending on the point of the price cycle at which they enter the market. Conceivably, what we observe may not be the result of a lag in expectations, but rather a manifestation of administrative "red tape."
more cool calculations. Flexibility is afforded them because transportation is an input to further inputs and conceivably they could reschedule runs, deplete inventories temporarily at the refinery, or even postpone delivery to their customers. What is more, the fact that at any moment of time they own vessels for a substantial portion of their transportation needs and have an equally substantial portion on long-term and consecutive-voyage charters, usually running over the immediate future, allows them a flexibility not afforded the independents. ¹ Finally, the independents are fighting for a share of the transportation market and cannot increase their share without taking the risk of excess capacity. ² But what is the excuse of the oil companies, who consider shipping as an ancillary evil?

The hysteria of the oil companies does have some basis however. The opportunity costs involved, in case of disruption of transportation, are so high that the producers are willing to pay the ransom. The cost of the Middle East oil, which is the most transportation intensive, was once estimated at 25 cents per barrel, ³ only a small fraction of the cost of competing oils.

¹For the period of 1954 to 1957, the oil companies controlled either through ownership, time charters, or consecutive-voyage charters between 80% and 91% of the total world fleet.

²The irony is that most of the risk during the Suez crisis was taken over by the oil companies, which provided long-term charters for ships not even contracted for. The independents with the oil company's signature on the charter could mortgage the hire and thus obtain money for building the vessel. According to information provided by one of the banks that specializes in such loans, in some cases the charter was so high that the bank could afford to give up to 90% of the cost and still get its money back from the net hire in five to seven years--and this with an economic life of the vessel of approximately 25 years.

³This figure was quoted in Le Prix Des Produits Petroleurs en Europe Occidentale, study prepared by the Secretariat of the Economic Commission for Europe, United Nations, Geneva, March 1955, p. 17. The figure was derived from data contained in the 1952 Oil Agreement between Iraq and the Iraq Petroleum Co. In addition to the cost of production, there was at that time a royalty of 23 cents per barrel. See also Ozanne Heury, "Super-Tankers Threaten United States with $2 Middle East Oil," World Oil, April 1949, p. 51.
Furthermore, refinery shutdowns are costly, and shut-in crude in the Middle East could benefit no one, be it the consumer, the producer, or the countries' political rulers.

As in the case of the shipbuilders, there are also indications of initial inelasticity in the expectations of the independents with respect to charter rates. Of course, not all of them move at the same time from the inelastic to the elastic part of their schedule. For example, during the Suez crisis the expectations of the Greek shipowners\(^1\) turned elastic too soon; they have been proven wrong, together with the oil companies, whose over-all behavior indicated almost infinite elasticity of charter-rate expectations.

The over-all (shipbuilding and chartering) behavior of the majority of the independent tanker owners, seems to be rational, though asymmetric, if we assume that the strategy of the oil companies is known and that specific vessels or shipbuilding contracts are necessary for charter agreements. When the charter-rate elasticity of expectations for the oil companies is greater than one (expectations elastic), and the behavior of the companies is consistent, the best strategy for the independents is to behave as if they have elastic shipbuilding-cost expectations,\(^2\) even though they may not. Such strategy will be rational if the total premium that they expect to pay in order to build at time \(t_0\) is less than the net value of the discounted stream of the premiums that they expect to receive from its initial charter. They will thus have the


\(^2\)In many cases the independents have not ordered the ship until they secured a charter for it. They have, therefore, quite a lot to gain and relatively little to lose by accepting such an arrangement. The extent of the risk in such case is determined by the level of the rate and the length of the charter.
tonnage to satisfy the increase in demand for future deliveries (of charters) that was triggered by a short-term excess demand, but at the same time they are contributing to the long-run instability of the market.

The fact that the time period over which rates will be low is extended with each additional vessel built does not seem to enter into the independents' planning for at least two important reasons:

(a) The tankship transportation markets are not well organized consequently "prudence" (in view of the consequences of overbuilding) does not prevail. And this, because the independent shipowners do not realize the interdependence of their behavior at the time of the decisions.

(b) As long as the original time charter agreement gives a good probability that the major part, if not all, of the initial investment will be recovered in the first few years of the life of the vessel, then the independents will be foolish not to invest. Most charters granted by oil companies during the Suez Canal crisis were at such high rates and of long enough duration to guarantee recovery of the investment (even at high shipbuilding prices) in approximately seven years. Consequently, and even if the independents realize the interdependence of their plans, they should invest under such circumstances.

In order to analyze the consequences of a decision to build "now versus later" one must divide the planning horizon into five parts.

(i) The time period \(m\) of the initial charter agreement of duration \(k\), over which the vessel will be operating if delivered at time \(t_o\) at a cost \(C_o\), versus being delivered at time \(t_m\) at a cost \(C_m\).

(ii) A time period starting at \(t_m\), the time that the vessel will be delivered at a cost \(C_m\) if not built at \(t_o\), and extending up to \(t_k\) (that is to say the period of overlap of the original time charters of the alternative vessels).
(iii) The time span between \( t_k \) (the point of expiration of the original charter of the early vessel) and \( t_{k'} \) (the point of expiration of the charter of the late vessel).

(iv) The time period between \( t_{k'} \) and \( t_n \) (the point of expiration of the life of the early vessel), and

(v) The time span between \( t_n \) and \( t_{n+m} \), that is to say the number of years by which the new vessel will outlast the old.

Before we proceed with the analysis let us denote (and also summarize previous relevant notations):

\[
R_o = \text{the yearly time-charter revenue of the early vessel.}
\]

\[
R_m = \text{the yearly time-charter revenue of the late vessel.}
\]

\[
OC = \text{as the out-of-pocket operating costs of the early vessel per year.}
\]

\[
OC' = \text{as the out-of-pocket operating costs of the late vessel per year.}
\]

\[
R_1 = \text{the long-run time-charter of spot-rate revenue that is expected to prevail beyond the initial time charter agreements.}
\]

\[
k = \text{the duration of the initial charter of the early vessel.}
\]

\[
k' = \text{the duration of the initial charter of the late vessel.}
\]

\[
n = \text{the life of the vessels in years.}
\]

\[
C_o = \text{the cost of the early vessel.}
\]

\[
C_m = \text{the cost of the late vessel, ordered } m \text{ years later.}
\]

\[
S = \text{the scrap value of the early vessel at time } t_n.
\]

\[
S' = \text{the scrap value of the late vessel at time } t_{n+m}.
\]

\[
i = \text{the cost of capital or subjective rate of return.}
\]
The relevant considerations during the various time periods (i) through (v) that we must use later are:

(i) \[
\sum_{t=1}^{m} (R_o - OC)_t (1 + i)^{-t}(1 - \text{tax rate}) + \sum_{t=1}^{m} (C_o/n)(1 + i)^{-t}(\text{tax rate}) \\
- C_o + C_m (1 + i)^{-m}
\]

(ii) \[
\sum_{t=m+1}^{k} \left[ (R_o - OC) - (R_m - OC') \right] (1 + i)^{-t}(1 - \text{tax rate}) \\
+ \sum_{t=m+1}^{k} (C_o - C_m)/n (1 + i)^{-t}(\text{tax rate})
\]

(iii) \[
\sum_{t=k+1}^{k'} \left[ (R_o - OC) - (R_m - OC') \right] (1 + i)^{-t}(1 - \text{tax rate}) \\
+ \sum_{t=k+1}^{k'} (C_o - C_m)/n (1 + i)^{-t}(\text{tax rate})
\]

(iv) \[
\sum_{t=k'+1}^{n} (OC' - OC)_t (1 + i)^{-t}(1 - \text{tax rate}) \\
+ \sum_{t=k'+1}^{n} (C_o - C_m)/n (1 + i)^{-t}(\text{tax rate}) + S(1 + i)^{-n}(1 - \text{tax rate})
\]

(v) \[
\sum_{t=m}^{n+m} (R_o - OC')_t (1 + i)^{-t}(1 - \text{tax rate}) + \sum_{t=n}^{n+m} (C_m/n)(1 + i)^{-t}(\text{tax rate}) \\
+ S'(1 + i)^{-(n+m)}(1 - \text{tax rate})
\]

If:

(1) \((i) + (ii) + (iii) + (iv) - (v) \geq 0\)

and

(2) \[
\sum_{t=1}^{k} (R_o - OC)_t (1 + i)^{-t}(1 - \text{tax rate}) + \sum_{t=k+1}^{n} (R_o - OC)_t (1 + i)^{-t}(1 - \text{tax rate}) \\
+ (C_o/n) \sum_{t=1}^{n} (1 + i)^{-t}(\text{tax rate}) + S(1 + i)^{-n}(1 - \text{tax rate}) - C_o \geq 0
\]
then the independents should invest even though their shipbuilding-cost expectation may be inelastic.

In the above formulations we made the assumption that \( R_f \) is the same for both vessels. Our analysis is not dependent on such an assumption, but it was made because it agrees with empirical realities. First of all the time difference between \( t_K \) and \( t_K' \), (the difference between the expiration dates of the two alternative original charters) is not great. Empirical evidence (already presented) shows that the average duration of time charters transacted during periods of high rates is approximately 15.5 months longer than the duration of the time charters signed during low rates. If we add to the duration of the charters the lead time between agreement and vessel delivery then the differences increases to 30 months.

Past history shows that spot rates and shipubilding costs do remain at high levels longer than 20 months. Consequently, the value of \( m \) is expected to be between two and three years, and under the conditions postulated for our analysis \( R_f \) will be approximately the same for both vessels. Furthermore, we must not forget that the lead time can be manipulated within limits.

To the extent that the rate elasticity of expectations of the charterers is greater than unity, the satisfaction of both conditions is guaranteed and is only a matter of time on a rising market. During the downturn, orders will be postponed unless \( (C_m (1 + i)^{-m} - C_o) > 0 \) is large enough to counterbalance the negative rate effect, a condition that is unlikely to occur since tanker rates fluctuate much more than shipbuilding costs. We would thus expect postponement of orders and even cancellations on the downturn. Furthermore, during depressed periods the charterers practically withdraw from the market;
hence the whole question of the existence of a time-charter rate is almost entirely academic. Even if we do find an \( R_o \) and \( R_f \), it is very improbable that this fact will satisfy the conditions of inequality (2).¹

Before leaving the discussion of inequality (2) we would like to use it and resolve a seemingly paradoxical occurrence. We can show that the average spot rate over the life of many vessels currently operating will be below the vessels' long-run average cost. Many people observing this cannot understand why "people are so stupid to invest in tankers." Relationship (2) will help us realize that the investors are not stupid after all. What the cursory observer does not realize, is that many of the vessels operating in the spot market have secured over their life span at least one long-range time charter at rates high enough to help recover most, if not all, of the fixed investment. Once the investment is recovered, then the vessel can afford to operate below long-run average cost as long as the rate is above out-of-pocket cost.

On the basis of the intrinsic characteristics of the tankship markets we can make a very strong statement, that the probability is very great that the average spot rate applicable to any vessel over its life span will be lower than its long-run average cost. What is strange is that only very few of the most astute independent operators see in this the opportunity for an arbitrage and sign time-charter agreements at high rates which they fulfill by entering the spot market.

Our conclusion that the independents should order vessels even when their shipbuilding cost expectations are inelastic was based, among other things, on the very fundamental assumption that specific vessels or contracts for such vessels are necessary for the consummation of charter agreements. However, we

¹See The Financial Times of Thursday, April 17, 1958 "Outlook for Shipping--Mr. Niarchos' Views."
find that this assumption is not universally true, indicating that on the average the expectations of the independents in the shipbuilding market are elastic rather than inelastic. That is to say they behave like buyers. Otherwise, the independents would be found selling short on the upswing, namely signing time-charter agreements but postponing orders until later.

During the period covered by this study, and especially during periods of high rates, many time charters were given specifying the vessels desired in the most general terms—specifying for example, just size and nothing more—rather than naming specific ships, but the independents have lost potential fortunes by choosing to run to the bank first and then to the shipbuilder.

Consequently, whether the shipbuilding cost expectations of the independents are elastic or inelastic, they are manifested as elastic, which leads us to the following observations and rules that relate final market demand to derived demand.

1. In order to determine the behavior of buyers and sellers in a derived market, one must look into the final market.

2. If the users' price elasticity of expectations in the final market (with respect to a change in own price) is greater than unity, then the elasticity of expectations of the users with respect to the cost of the derived factor will also be greater than unity. If it is less than unity, it will be so in the derived market also.

3. If the price expectations of the suppliers of the final product are less than unity, then expectations with respect to the derived factor cost will in all probability be revealed as being symmetric.

1This manifestation of elasticity indicates that the oil companies should not always consider the reaction of the independents as an external guide for action. Such a practice often leads to a vicious circle of reasoning.
with those of the users of the final product. If expectations are elastic in the final market, they will also be elastic in the derived market.

Our previous conclusions as to the "asymmetric symmetry" of expectations of buyers and sellers seem to hold with the independents and the oil companies. Table 5 shows how the independents led the oil companies into the shipbuilding market and then again in withdrawing from it.\(^1\) That the net result of the expectations of both oil companies and independents in the shipbuilding market is "final-market-rate" elastic is also shown by the Fairplay semi-annual index of shipbuilding costs.\(^2\) Figure 14 shows that both Fairplay cost indices move in the same direction as do spot rates, and that the cost of building the Fairplay standard ship is a smoothed function of the price of a "stock boat."\(^3\)

If we forget the impact of factors that affect the over-all trend (in our case inflation), we notice that when charter rates are high the price of the stock boat is higher than the cost of building one, and vice versa. Unfortunately, we cannot exactly determine whether this difference is due to objective economic reasons or to expectations. In other words, the premium during periods of high rates may be due to:

1. The time cost of income that a ready vessel can earn while another vessel is being build.

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\(^1\)See also *Petroleum Press Service*, September 1958, pp. 326-329.

\(^2\) *Fairplay* semi-annual issues (January and July) 1949-1958.

\(^3\) A "stock boat" is a finished vessel on inventory. This idea is used for comparative purposes only, because inventories of new vessels are a very rare phenomenon.
2. The loan value of the charter of an operating vessel which is bigger than that of vessel under construction, because the latter does not earn income during the construction period; or

3. The premium that oil companies are willing to pay to satisfy their assumed urgent needs.

Under low rates, the major objective reason that may explain such deviation is the cost of idleness of a ready vessel during the construction period of a new one. On the other hand, we must not exclude the possibility that at least part of such deviation between the two cost indices of Figure 14 may be caused by the inelastic charter-rate expectations of the independents.

The fluctuations in the cost indices of Figure 14 could be the result of and are consistent with the behavior of either the independents or the oil companies, because:

1. If the observed fluctuations are the result of the behavior of the independents, they show that their expectations with respect to shipbuilding cost are, or are manifest as elastic and they thus prefer to buy now.1 This behavior, incidentally, is consistent with both elastic charter-rate expectations (if they buy the ship to "store" it)2 or inelastic (if they buy the ship to take advantage of present rates that they do not expect in the future). The eagerness of the independents to charter their vessels on a long-term

1 Escalation clauses are included in the contracts only on the upswing. In some cases, 100% of the cost is covered by such clauses, which means that the quoted price represents only the basic cost of the shipbuilding contracts.

2 This is only a theoretical possibility; storage in conjunction with our discussion should imply chartering on spot and postponing time charter for the proper future period. However, there is at least one case where the shipbuilders have built a stock boat (a vessel that has not been ordered) to utilize excess capacity caused by the depressed markets in 1958. See J. I. Jacob's World Tanker Fleet Review, 31st December 1958, p. 4.
basis shows that they buy vessels to use them and not to store them. We can conclude, therefore, that they have inelastic charter-rate expectations, at least for the main part of their expectations schedule.\(^1\) The existence of inelastic expectations in the charter market, however, is a sufficient condition as we have previously shown for a revealed elastic schedule in the tankship building market.\(^2\)

2. If, on the other hand, the fluctuations are due mainly to the behavior of the oil companies, they are again the result of elastic expectations--but now in both markets, the main one being of course the tankship service market.

Thus, whether the movements in the prices of ready vessels and the cost of building are due to the behavior of the independents or the oil companies or both, they are manifested as the net result of elastic expectations in the tankship building markets.

As for the chartering market (where the behavior is opposing), empirical evidence shows that the independents moving on the inelastic part of their schedule were at first adding to their orders chiefly as they were chartering. Later, in exuberance--"after all, no one expected this collapse in rates,"\(^3\)--they began placing orders with no charter security and with promises for escalations and cash on delivery. At the end of the first quarter of 1958,

\(^1\)We are informed that the independents did not particularly like time charters of less than five years' duration.

\(^2\)We can even make a stronger case (but it is not necessary) because as we have already argued evidence points out that the independents behave like buyers and betray real not only manifest elastic expectations in the tankship building markets.

\(^3\)Niarchos' interview with The Financial Times, op. cit.
only 41.8% of all the ships under construction were "fixed" (had charter agreement waiting). Listed by flag of registry, the percentages of chartered new buildings were as follows:  

<table>
<thead>
<tr>
<th>Flag</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>British</td>
<td>21%</td>
</tr>
<tr>
<td>Liberian, Panamanian</td>
<td>31</td>
</tr>
<tr>
<td>Norwegian</td>
<td>58</td>
</tr>
<tr>
<td>Swedish</td>
<td>69</td>
</tr>
<tr>
<td>French</td>
<td>50</td>
</tr>
<tr>
<td>Italian</td>
<td>60</td>
</tr>
<tr>
<td>Danish</td>
<td>25</td>
</tr>
</tbody>
</table>

The number and the characteristics of time charters that are contracted on high versus those on low rates provide other interesting evidence on the expectations of the oil companies versus those of the independents. For the period of 1950 to 1957, the consistent time charter data that we will analyze later are comprised of 897 observations, of which 304 were contracted when the spot rates were low and 593 when high. In terms of monthly averages the respective figures are 6.5 and 16 transactions. The lead times (from agreement to ship delivery) were 10.5 months and 24.1 months, respectively, and the duration of the time charters was 45.5 months for the period of low rates versus 61.1 months for the period of high rates. Variance analysis shows that we can say with 99% confidence that the two means are different.

1The data were provided by Captain Conway of the Cosmopolitan Transit Lines. The British flag percentage seems to be low. Probably orders for then newly formed tankship companies of British Petroleum and Shell were considered as unfixed.
This fact, in our estimation, indicates elastic rate expectations on the part of the oil companies and inelastic for the independents.

With the above as background, one can appreciate the impact of the behavior of the oil companies and the independents on tanker rates. Expectations can swiftly bring about sequential shifts in demand, but because the supply schedules, especially in the short run, cannot change without the passing of time, rates move from the bottom to the peak and vice versa in a matter of months.

As we shall see later, the normal static supply schedule is very elastic up to the point of full capacity\(^1\) (this is part of the normal long-run schedule) and then becomes very inelastic (i.e., it follows the short-run schedule). This shape exists because the most efficient unit in operation (even if one assumes no ancillary technological constraints) is not large enough to be a significant percentage of total capacity. It can be duplicated; hence, entry is not restricted. Beyond normal capacity, however, the only way one can increase capacity in the short run is by increasing the speed at which the vessels are operated, which is a very costly proposition.\(^2\)

The result, under the circumstances that we have sketched here, is that a shift in demand to the right of the point of full capacity can send the short-term

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\(^1\)The definition of full capacity is vague because of the various dimensions of capacity. We will return later to this discussion.

\(^2\)Normal speed, in practice, is defined as the point beyond which the speed can increase only by a proportionate increase in shaft horse power to the third power and above. Fuel consumption varies directly with SHP; hence a speed of \(S (1 + x)\) can only be achieved at a cost of \(F (1 + x)^n\) where \(n > 3\).
rates skyward. This rise, in turn, triggers new orders for ships and also shapes expectations about future rates. But rates also move downward, and one can visualize what will happen if expectations about the future are not realized.

Before ending this section, let us mention what policy planners of oil companies said on several occasions during interviews. They claim that they do not attempt to maximize profits, but to minimize the cost or penalty of a wrong decision. One of them went so far as to admit that they operate under the assumption that they are always making the wrong decisions and plans. They therefore behave, in their implementation of plans, in a manner that they hope will minimize the penalties. On the basis of this type of thinking, and with constant marginal utility of money one will undoubtedly arrive at an optimum solution by including among the penalties of the alternatives the opportunity costs of decisions.¹ There is one important qualification, however. This solution will be arrived at only if there is a symmetry of expectation in assigning values in the process of arriving at a certainty equivalent.² If this preference toward risk minimization tends to ascribe relatively more value to the avoidance of anguish because of losses (by "imaginative anticipation," to use Professor Shackle's terminology)³ than to the joy due to the anticipation of gains, then asymmetry will arise in the translation of the expected gains of

¹ In this way, for every pair of alternatives the revenue side advantages of one alternative will appear as penalties in another.

² For a description of the process, see any of the many articles on expectations and uncertainty. Professor Shackle in the Time in Economics, North-Holland Publishing Company, Amsterdam, 1958, provides a whole chapter on "Decision and Uncertainty," pp. 35-66 and also a reading list on pp. 62-65. Also see Baumol, op. cit.; pp. 86-91 and his bibliography.

one alternative into opportunity costs of another. Under such circumstances, risk minimization and profit maximization will not give identical solutions.¹

The so-called principle of conservatism or conservatism that is applied in managerial decision-making may be due largely, if not completely to an asymmetry in assigning weights to the avoidance of anguish versus the experiencing of joy in the process of translating expectations. This principle will not only result effectively in higher costs relative to revenues at the different points of time over which the decisions will rule, but will also dictate higher discounting rates for the revenue streams as compared to those applied to the cost streams.

The conservative entrepreneur tends to believe that the forecasted value of costs of a particular year will prove to be below the actual, and the forecasted revenue above the actual, not because of price movements but because of the greater weights assigned to the avoidance of anguish caused by losses. This process of weighing costs and revenues leads him to a conservative forecast. Then, in order to cope with the uncertainty inherent in the stationary assumption on the basis of which he has developed his forecast, he will apply a discounting factor to the streams of costs and revenues. Usually the uncertainty due to dynamic phenomena is incorporated into the expected rate of return; but because

¹If we consider more dimensions to the uncertainty problem, namely, uncertainty with respect to risks inherent in plans, and uncertainty with respect to plan intensity, then the deviation from profit maximization because of these asymmetries will be greater.
of the asymmetry of anguish versus joy, the effective discount rate applied to
the cost stream is lower than that applied to the revenue stream.\(^1\) The above
process is not, of course, applied either consciously or consistently. In
fact, the inconsistency in the application of such a process may be one of the
main factors that lessen the impact of bad decisions.\(^2\)

It is not unnatural to expect policy planners to use risk minimization
(in terms of certainty equivalent) because losses are concrete and are more
painful than the thought of profits that would have been realized had the
decision been different. If a decision has not resulted in eventual losses,
probably no one will question its wisdom or compare it with former alternatives
now perhaps forgotten.\(^3\) The accounting system of the firm certainly will not
pick up and trace the consequences of alternatives that have not been implemented,
nor will it point at that although a decision led to adverse consequences was
dictated by the most efficient decision-making processes. As a result executives
have a greater probability of survival if they avoid risk and aim for the status
quo.

Finally, the behavior of the operatives in the tankship markets (elasticities
of expectations, ordering, chartering, etc.) may prove to be a little more

\(^1\) Those whose imaginative anticipation equates on a "one-to-one" basis a
present loss with a future one, apply zero discount rate to the cost stream.

\(^2\) On the basis of what we have said concerning asymmetry, consistency under
conservatism implies non-cancellation of the revenues and costs of a particular
year. It also implies that the expected revenues of one alternative cannot be
considered as opportunity costs of the other alternative but should be netted
against other revenues.

\(^3\) Another and more single explanation of the risk minimization behavior may
be found in the shape of the entrepreneur's utility surface. He may be at a
point where the slope is zero.
rational than our analysis has indicated, if examined in the context of an expanding industry. With a positive long-term trend, mistakes will be washed out. The question, however, arises: Why make such costly mistakes and look to the long-term trend for salvation?

I. Spot Rates and Tanker Deliveries

If we assume a normal period of between fifteen and twenty-four months for the completion of a vessel,\(^1\) it follows from our previous findings that the peaks in tankship deliveries will lag behind the peaks of orders placed by at least the average shipbuilding lead time. If we now allow for the "frictional" postponement of deliveries at times of saturated construction berths and also consider some lag between spot rates and orders placed, we will find that vessels will be delivered in increasing numbers that reach their peak some two to two-and-a-half years after the spot rates have passed their peak.

Figure 15 presents a plot of monthly spot rates (per 1000 ton-miles) versus deliveries in terms of T-2 equivalents.\(^2\) It is obvious that the upward trend in deliveries had not exhausted itself as of the end of 1958. If we assume an average lead time in shipbuilding of eighteen months, on the basis of the pattern of orders placed, one could expect that the rate of deliveries would not decrease until sometime in 1959. From all indications, the 1959 deliveries will exceed 7,000,000 DWT., or 500 T-2 equivalents. If we compare Tables 7 and 8, we notice that even if the delivery peak is reached in 1959, 1960 will still be second only to 1959.

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\(^1\)This average lead time changes. During the early post-war years, it took on the average three years to build a vessel; by 1956 the lead time was reduced to about two years, and in 1958 it was between fifteen and eighteen months. The latter figure may have been inflated because of the desire of shipowners to postpone completion as much as possible during depressed market conditions.

\(^2\)The data were provided by the Transportation Coordination Department of the Standard Oil Company of New Jersey, which compiled these from Lloyd's Register.
The data used in Tables 7 and 8 came originally from Lloyd's Register Shipbuilding Returns¹ and are based on scheduled deliveries for vessels of 6,000 DWT. and over. Usually, however, there is an overflow, and John I. Jacobs & Company Ltd. in their World Tanker Fleet Review² report the following concerning tankers of 10,000 DWT. and over as of December 31, 1958.

<table>
<thead>
<tr>
<th>Year</th>
<th>No.</th>
<th>DWT.</th>
<th>T-2 Equiv.</th>
<th>DWT.</th>
<th>T-2 Equiv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>256</td>
<td>7,992,850</td>
<td>5542</td>
<td>7,000,000</td>
<td>475</td>
</tr>
<tr>
<td>1960</td>
<td>190</td>
<td>6,753,650</td>
<td>443</td>
<td>6,250,000</td>
<td>406</td>
</tr>
<tr>
<td>1961</td>
<td>148</td>
<td>5,532,450</td>
<td>372</td>
<td>5,000,000</td>
<td>336</td>
</tr>
<tr>
<td>1962</td>
<td>69</td>
<td>2,882,300</td>
<td>198</td>
<td>4,250,000</td>
<td>292</td>
</tr>
<tr>
<td>1963</td>
<td>40</td>
<td>1,842,850</td>
<td>128</td>
<td>2,500,000</td>
<td>173</td>
</tr>
<tr>
<td>1964/5</td>
<td>13</td>
<td>628,100</td>
<td>44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The significance of the above figures is that most of these orders were placed in response to changes in spot rates, but because of the shipbuilding lead time these tankers will be entering the market at times when economic or market conditions may not be very favorable. Only if the short-term rates reflect accurately the long-term expectations will disaster be averted. In case the short-term rates are the result of only short-term market interactions, then the peak in orders placed will occur at or after the peak in short-term rates (because of the elasticity of expectations), and consequently deliveries will reach their peak long after the impetus that generated them has disappeared.

¹The data were provided by the Transportation Co-ordination Department of the Standard Oil Company of New Jersey, which compiled these from Lloyd's Register.

²December 31, 1958, issue, pp. 4-5.
Unless another unexpected need appears to utilize this new capacity as it enters the market, its impact will be destabilizing and very painful.

The lessons of the past are very easily forgotten, as is shown by the works of Koopmans, Tinbergen, and recently, Westinform Service. Westinform Shipping Report No. 118 attempted an analysis to show a parallel between the shipping crises of the 1930's and of the "post Suez" period. The report does not deserve much praise for its analytical insights. It contains some statistical information, however, which, although it may not qualify on the basis of scientific standards of accuracy, is indicative of a parallel between the two periods. The conclusions reached by Westinform are all expressed in terms of leads and lags from the peaks and troughs of "World Seaborne Trade," but very little explanation is given of such leads and lags. Then, assuming that the same relationships apply to the present period, Westinform makes projections to predict recovery in the tankship markets.

The relationship between oil movements and transportation needs is indisputable. One can argue, nevertheless, that many of the links in the chain

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1 Lessons of the 1930's, September 1958, 7 pages. This report was the sequel to an article written by the President of W. G. Weston Ltd., Mr. W. G. Weston, for the Fairplay of July 3, 1958.

2 It defines peaks and troughs by "highest and lowest points," which depend on the time period chosen, neglecting any intermediate fluctuations which may qualify as cycles; it neglects shipbuilding construction, but attempts to relate tonnage launched with "World Seaborne Trade." It indulges in a lot of implicit theorizing and arrives at conclusions by definition. For example, it defines "Effective World Fleet" as total fleet less ships idle and then concludes that changes in the "effective size of the world fleet almost exactly correspond with changes in seaborne trade, although the operating factor, freight rates, is related in a much less exact manner," op. cit., p. 5.

3 When compared with data included in Koopman's Tanker Freight Rates and Tankship Building, pp. 186-204, the Westinform data (excluding faulty definitions of peaks) appear out of phase by about three months to a year.
of cause and effect are more revealing than the end points. Our contention is that seaborne trade affects the short-term demand for transportation, and the effect is naturally reflected in short-term rates. The latter conditions expectations that generate orders for vessels when rates are rising, and cause both rates and orders to spiral. The ordered vessels, however, because of the shipbuilding lead-time, increase future rather than present capacity. Also, we have provided evidence that the relationship between rates and orders placed is relatively strong and that orders begin to decline only when or after the rates do. Consequently, the increments to future capacity will continue beyond the point where the need that generated them has been satisfied or has even created surpluses. It is abundantly clear that the impact of deliveries which will appear a few years later, after, let us repeat, the satisfaction of the need that initiated them, will create chaotic conditions.

The net result of the impact of rates on orders can be seen in Figure 15 and in Figures 16 and 17. Figure 16 shows the time-series comparison between changes in orders outstanding and spot rates. We notice that the peak in the changes to the backlog of orders was reached seven months after the peak in rates. To illustrate the relationship between the magnitudes of orders outstanding and the tonnage in existence during those periods, we show in Figure 17 the time series of orders as a percentage of total fleet and working petroleum fleet. During the Suez Canal frenzy, orders flooded the shipyards to such an extent

1The working petroleum fleet is defined as vessels operating. It is composed of total tonnage minus government-owned and special purpose vessels, and ships idle over 30 days (for repairs or lay-up). The working petroleum fleet figure is somewhat inflated by the inclusion of all repairs and maintenance of under 30 days.
Figure 17

- Spot rates (dotted line)
- Orders outstanding as % of total fleet (solid line)
- Orders outstanding as % of working fleet (dashed line)
that at the **peak** in September 1957, orders outstanding were about 94% and 112% of the total fleet and working petroleum fleet, respectively. Such a backlog is indeed staggering if we realize that the fleet at this time was approximately equal to 2600 T-2 equivalents. The relationships depicted in Figure 17 occurred in spite of the new records in deliveries that were being established during this period. In Figure 18 and 19 we present a scatter diagram of the net changes in orders outstanding (in terms of T-2 equivalents) versus spot rates, for the periods 1948-1953 and 1954-1958, respectively. The results indicate that even the **net changes** are positively correlated with rates.

The arguments presented above are in general agreement with those presented by Koopmans and Tinbergen in their classic works.¹ The difference between our analysis and theirs is not of a qualitative nature but rather rests on the degree of quantitative evidence, the shape of our demand schedule (due to dynamic expectations), and the particular reaction patterns of the operatives.

**J. Spot Rates and Vessels Scrapped**

Prior to this point, we have discussed the factors that cause shifts to the right in the supply schedule of tonnage. We shall now turn to the causes of shifts to the left, or contraction of capacity.

Contraction of supply may occur either permanently or temporarily; that is, it may affect either the long-run or the intermediate supply schedules. In the former category we may classify scrappings or permanent retirement of vessels, ¹See Koopmans' *Tanker Freight Rates and Tankship Building*, pp. 160-172, where Tinbergen's work is also discussed.
while in the latter we may include slow-downs, extended repairs, conversions to dry cargo, grain carriers, etc., and finally tie-ups. Some of the aforementioned factors, such as conversions, are of relatively little importance; and extended repairs and slow-downs, although quantitatively important in the aggregate, are variable within narrow and more or less definable limits.

We will analyze in this section the factors that govern permanent retirements, leaving the contractions of short-run and intermediary nature to subsequent discussion. Some aspects of permanent retirements (scrappings) of vessels have been presented in conjunction with our discussion of their impact on orders placed. We have pointed out at that time that the relationship between the short-term and the expected rates over the remaining life of the vessels, on the one hand, and out-of-pocket cost of operation and tie-up, on the other, determines whether a vessel will be scrapped, tied up, or operated.

As there is so much fluctuation and uncertainty in rates in the long run, it is quite probable that the owners of vessels base their expectation on the only concrete evidence that they have; that is to say the existing spot rates. Therefore, we would expect the number of vessels scrapped to be inversely related to spot rates. Furthermore, if our previous theoretical conclusions are valid, the age of vessels retired and the short-term rates should be positively correlated.

Table 12 presents the yearly data for the number of vessels sold for scrap, the capacity which indicates the average size of the vessels involved, the average life of such vessels, and the average spot rate for each year between 1947 and 1958. The same data are plotted in Figure 20 and show very convincingly that the number of vessels scrapped and the spot rates are moving in the opposite
direction, while the age of the vessels retired increases with the spot rates. The downward trend in the average age of vessels retired is caused by the advance in technology, which continuously changes the size composition of the tanker fleet.

As we have stressed in discussing retirements and orders placed, retirements and replacements are two distinct actions from the economic point of view and should be so treated. Failure to do so will result in erroneous theoretical conclusions, such as those reached by Koopmans and Einarsen on this subject.  

By defining as "replacement" any order that preceded or followed by 24 months the sale or retirement of a vessel, Einarsen's data, Koopmans concluded, show "that the conditions which stimulate new investment also favor replacement."  

There is no theoretical reason requiring sale or retirement of a vessel only after an order for its replacement has been placed or the replacement itself has been received. Or, to invert the argument, there is no reason why the placing of an order or the receipt of a presumed replacement should cause the economic value of an existing vessel to vanish. As the day follows the night so do low rates follow years of inflated rates. Because these rate fluctuations occur often and are violent, and rates rise and fall in less than 24 months, Einarsen found enough sales and retirements to associate with orders placed and vice versa. If it were not for these violent changes, we are confident that the data would have refuted such an hypothesis.

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1See Koopmans, *Tanker Freight Rates, and Tankship Building*, pp. 156-158.

2Ibid., p. 158.
### TABLE 12

**Vessels Scrapped and Spot Rates**

**Yearly Data**

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Vessels</th>
<th>T-2 Equivalent</th>
<th>Average Age in Years</th>
<th>Ave. Yearly Spot Rate Per 1,000 Ton Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>8</td>
<td>3.1</td>
<td>29.5</td>
<td>2.20</td>
</tr>
<tr>
<td>1948</td>
<td>4</td>
<td>1.8</td>
<td>29.5</td>
<td>2.66</td>
</tr>
<tr>
<td>1949</td>
<td>42</td>
<td>19.0</td>
<td>30.1</td>
<td>1.12</td>
</tr>
<tr>
<td>1950</td>
<td>16</td>
<td>6.1</td>
<td>32.0</td>
<td>1.52</td>
</tr>
<tr>
<td>1951</td>
<td>6</td>
<td>2.3</td>
<td>38.2</td>
<td>3.04</td>
</tr>
<tr>
<td>1952</td>
<td>5</td>
<td>2.0</td>
<td>36.6</td>
<td>2.35</td>
</tr>
<tr>
<td>1953</td>
<td>56</td>
<td>25.0</td>
<td>29.6</td>
<td>.94</td>
</tr>
<tr>
<td>1954</td>
<td>70</td>
<td>37.9</td>
<td>29.0</td>
<td>.89</td>
</tr>
<tr>
<td>1955</td>
<td>55</td>
<td>25.7</td>
<td>30.2</td>
<td>1.32</td>
</tr>
<tr>
<td>1956</td>
<td>10</td>
<td>4.2</td>
<td>31.4</td>
<td>2.44</td>
</tr>
<tr>
<td>1957</td>
<td>16</td>
<td>8.0</td>
<td>26.4</td>
<td>1.52</td>
</tr>
<tr>
<td>1958</td>
<td>37</td>
<td>20.5</td>
<td>25.1</td>
<td>.68</td>
</tr>
</tbody>
</table>

**Note:** Of the 1958 data the average life of vessels scrapped by the oil companies was 21.9 years versus 28.9 for the independents.

**Source of Data:**

1. and 2, Transportation Co-ordination, Standard Oil Company, New Jersey
2. Register of Tank Vessels of the World, Standard Oil Company, New Jersey
3. For 1947 and 1948 Conrad Boe LTD, Oslo, Norway
   For 1949-56 United States Maritime Administration
   For 1957 and 1958 Addison Outwater Associates, New York
A small number of retirements will occur regardless of rates; however, the greatest number of such retirements will take place, we believe, on low spot rates, in spite of any orders outstanding for the owners of the vessels retired. Why should an owner who is able to secure a remunerative employment for his old vessel refuse it? On the other hand, if an operator sees that he has no prospects for remunerative employment for his vessel over what now seems to be its remaining economic life and therefore decides to retire the vessel instead of keeping it idle, why should he order a replacement if the prospects for employment of the new vessel when it appears in the market are not promising? Would he not naturally wait until he is somehow assured about the immediate future?

We have pointed this out on purely theoretical grounds before, and Figure 20 gives us empirical evidence that the correlation between rates and vessels retired is negative. Further, the average age of the vessels retired is positively correlated with rates and not negatively as the Einarsen-Koopmans argument would imply. If the variability in the average age of vessels scrapped is so great between years, is not this an indication that a uniform time period (24 months for example) between replacements and scrappings or scrappings and replacements is lacking? Why should there be a difference of over six years between the average lives of vessels scrapped in 1955 and 1958, respectively? If we accept such differences as part of calculated replacement-scrapping plans, we will in effect be asserting that the owners knowingly cut the economic life of their vessels, which is illogical. It is one thing to accept naivety, but this degree of irrationality is inadmissible.
To summarize briefly, we have already provided empirical evidence that spot rates and orders placed are positively correlated. The same relationship also exists between spot rates and fixtures (vessels hired). So the higher the spot rate, the greater the flood orders for both new vessel construction and rental of existing vessels. At levels such as those reached by spot rates on the up-swing even the most inefficient vessels can secure remunerative employment, consequently no one in his right mind will retire a vessel at high rates unless he has to do so. At low rates, when most of the retirements will take place because of the expiration of the economic value of vessels, retirements may not necessarily generate replacements but only reduce the existing surpluses. Technological innovations of substantial nature will be more likely introduced when rates are high and most of the new vessels are ordered. During periods of low rates, the pressure for technological changes will most probably be aimed at reducing the cost of operation of existing vessels, in order to increase their profitability and postpone the expiration of economic life of surplus vessels.

It appears, then, that replacement orders are the result of the expiration of the economic value of old vessels which is more likely to occur at low rates. But when replacements do occur, only under conditions of stationary stability would one expect a one-to-one correspondence between retirements and orders placed. In industries such as this, where the firms enjoy internal economies of "unit" scale, replacements on a vessel-for-vessel basis are surplus conducive.

Table 13 presents the average sizes of the vessels scrapped, delivered, and ordered yearly, for the years 1948 to the end of April 1959. The same data
are graphed in Figure 21. These exhibits are convincing evidence that replacements cause surpluses in the tankship markets. The average size of the vessels delivered during the various years was anywhere from two to four times as large as the average size of vessels scrapped. Even more impressive is the comparison between the sizes of vessels scrapped and orders placed: the average size of the latter in 1957 was 5.6 times greater than that of the vessels retired. One must not, however, forget that replacements are still a very small fraction of the orders placed, given elastic price expectations. One glance at column 2 of Table 12 will convince us that even if we assume that all vessels retired were replaced, such orders cannot account for more than 1% of all orders placed during periods of high rates when the avalanche of orders occurred.\(^1\)

Now that we have raised the issue of technology versus size, let us digress for a minute and observe that although economies of scale are necessary for the trend toward mammoth tankers, yet the speed of introduction of larger sizes does not always depend upon purely economic considerations. The pride and rivalry of the various tanker operators, especially independents, have contributed extensively to the rapid change from the era of the T-2 to that of the 100,000 tonner. It was not long ago that the war-built T-2 (16,500 DWT, and speed of 14.5 knots) was the queen of the seas. In 1948–1949, the shipbuilders were already delivering 27,000 tonners that could achieve average speeds of 16 knots. Three years later the industry was thinking in terms of 37,000 DWT. vessels,

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\(^{1}\) On May 1, 1959, despite cancellations, postponements, and conversions of over 3 million tons during the last quarter of 1958 and a record delivery of 2.5 million DWT. (163.3 T-2s) between January and April 1959, orders were outstanding for 718 vessels, a total of over 26 million DWT., equivalent to 1729.7 T-2s or approximately 55% of the total fleet (idle and operating) of January 1, 1959.


TABLE 13

Average Size of Vessels Scrapped, Delivered and Ordered

By Years 1948-1959

Average Size per Vessel
in T-2 Equivalent

<table>
<thead>
<tr>
<th>Year</th>
<th>Scrapped</th>
<th>Delivered</th>
<th>Ordered</th>
<th>Ave. Rate per 1000 Ton Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>.45</td>
<td>.80</td>
<td>1.12</td>
<td>2.66</td>
</tr>
<tr>
<td>1949</td>
<td>.44</td>
<td>1.07</td>
<td>1.06</td>
<td>1.12</td>
</tr>
<tr>
<td>1950</td>
<td>.38</td>
<td>1.01</td>
<td>1.04</td>
<td>1.52</td>
</tr>
<tr>
<td>1951</td>
<td>.38</td>
<td>.99</td>
<td>1.26</td>
<td>3.04</td>
</tr>
<tr>
<td>1952</td>
<td>.40</td>
<td>1.11</td>
<td>1.45</td>
<td>2.35</td>
</tr>
<tr>
<td>1953</td>
<td>.45</td>
<td>1.24</td>
<td>1.75</td>
<td>.94</td>
</tr>
<tr>
<td>1954</td>
<td>.54</td>
<td>1.36</td>
<td>1.96</td>
<td>.89</td>
</tr>
<tr>
<td>1955</td>
<td>.47</td>
<td>1.39</td>
<td>1.90</td>
<td>1.32</td>
</tr>
<tr>
<td>1956</td>
<td>.42</td>
<td>1.70</td>
<td>2.15</td>
<td>2.44</td>
</tr>
<tr>
<td>1957</td>
<td>.50</td>
<td>1.90</td>
<td>2.80</td>
<td>1.52</td>
</tr>
<tr>
<td>1958</td>
<td>.55</td>
<td>1.94</td>
<td>*</td>
<td>.68</td>
</tr>
<tr>
<td>1959 (Jan.-April)</td>
<td>N.A.</td>
<td>2.04</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

N.A.--Not Available

*Periods of extensive cancellations

Source of Data: Transportation Co-ordination, Standard Oil Company
New Jersey
For rates see Table 12
but one independent operator (Onassis) set his sights even higher. The Tina
Onassis, delivered in 1953, is 45,222 DWT. and achieves speeds of 16.5 knots.
Then came the challenge from another operator (Niarchos), the World Glory
(45,509), to which the former responded by building the ill-fated Al Malik
Saud Al Awal (46,548 DWT.).

While the rivalry that we mentioned was stealing the headlines, Ludwig
(National Bulk Carriers Inc. and Universe Tankships Inc.) quietly walked away
with the prize. Since the Sinclair Petroleo (56,080 DWT.) was delivered in
1955, Universe Tankships have held the record. Sinclair Petroleo was followed
in 1956 by the Universe Leader of 85,515 DWT. and in January 1959, by the
Universe Apollo of 104,500 DWT. ¹ To "challenge" Ludwig, Onassis ordered early
in 1957 two vessels of 105,000, and Niarchos one of the same size. These were
later changed to 106,500 DWT., but the post-Suez depression forced Onassis to
cancel his orders, ² and Niarchos to postpone action for a year. Niarchos' vessel, which is now being built, is the largest under construction. ³ One should
expect, however, that the race for size will not end here.

No matter how great the economies of scale achieved with vessels of 100,000
DWT., the industry cannot afford such inflexibility if it is applied universally.
Only regularly scheduled distant runs can be entrusted to such vessels, provided
the harbor facilities, storage capacity, refinery through-put capacity, and

¹There were three more vessels of 104,500 DWT. each under construction
for Universe Tankships, as of July 1959.

²Because these vessels were part of a "transfer out and build in U.S." agreement with the U.S. Government, Onassis got into trouble. To our knowledge,
final decision on one of the two vessels had not been taken as of July 1959.

³During the Suez crisis it was rumored that Niarchos requested from shipyards
details for a vessel of 160,000 DWT.; but together with the rates, rumors subsided.
market size permit their use. For this reason it is not expected that the number of such vessels will drastically increase in the near future, especially because of actions by the independents (unless of course they obtain first a charter agreement). It is more natural for the oil companies to own big vessels, because the uncertainty of their utilization in such rigid circumstances is less. Because no independent would take the risk of having such a tanker remain idle or operate in the spot market, most of the super tankers operate under long-term charters of ten or more years' duration.

Figure 20 also shows, on the basis of the 1958 data, that the average life of the vessels scrapped by the oil companies was 21.9 years versus 28.9 for the independents. This fact indicates that the oldest vessels used by the oil companies are not older or less efficient than those of the independents. From data furnished by the Transportation Coordination Department of the Standard Oil Company of New Jersey, we find that on January 1, 1959, 3.1% of the vessels owned by the oil companies were 21 years old or older. The corresponding percentage for the independent fleet was 5.1%. On January 1, 1958, the

---

1 Table 3 shows that the average size of the vessels under construction on account of the Oil Companies was 40,600 DWT., and that of the independent vessels 33,700 DWT. on January 1, 1959.

2 The history of the vessels of 65,000 DWT. and over shows the following: In 1957, five vessels of 65,000 and one of 85,000 were chartered for ten years by the Texas Company for Middle East--U.S. trade; two other vessels of 65,000 and 68,000 DWT., respectively, were chartered by the Standard-Vacuum (Stanvac) for 15 years for Far Eastern trade. In 1958, two 87,400 DWT. vessels were chartered for 15 years for Far Eastern trade by Stanvac. The Universe Apollo, according to the Shipping World, was to be delivered to the Gulf Oil Company for a 15-year charter to operate between the Persian Gulf and Japan. Source of information: Conrad Boe reports of Oslo Norway; Addison Outwater & Associates (Brokers) of New York, and the Shipping World and World Shipping, Vol. CXXXIX, No. 3415, Wednesday, December 10, 1958, London, p. 501.
relevant data were 3.8% for the oil companies and 5.8% for the independents. Because the oil companies have secure employment for a certain amount of tonnage, the 1958 data, if they are applicable to all other years, may reveal the competitive character of the tankship markets. As the labor cost of the oil companies is high relative to that of the independents, competition will force the former to scrap their vessels earlier.1

Another point that comes out of Figure 20 is worth mentioning. The average life of the vessels scrapped in 1958 has no parallel in the period under observation. This may be the result of a combination of the technologies of scale enjoyed by the industry, and the consequent obsolescence, and the extreme severity of the present depression in the tankship markets.

Finally, Table 13 shows that the average size of vessels scrapped is inversely related to tanker rates. This further strengthens our arguments that spot rates determine the greatest part of the retirements in a given year.2

In summary, we can say that retirements of vessels are negatively correlated with rates and for this reason are equilibrating. To the extent that they are quantitatively insignificant,3 however, the retirements have not caused in the past, and are not expected to cause in the future, sufficient contraction in the supply schedules to restore equilibrium in a depressed market.

1 The oil companies have an advantage over the independents in that they use bunkers which they themselves produce. This argument, however, will apply only in cases where bunkers are in excess supply.

2 The smaller vessels are usually less efficient, and hence are the first to be retired. As rates go down, relatively larger and larger vessels become uneconomical.

3 In the next chapter we will show that, because of the extensive inelasticity of the normal supply schedule beyond full capacity, small changes can prove very important. This is not in conflict with our present arguments because retirements occurring during periods of low rates are usually caused by existing surpluses, abundance of deliveries, and expectations which are rate elastic.
K. Spot Rates and Slow-Downs, Conversions, Repairs, and Tie-Ups

We shall now turn to the factors that affect the short-term and intermediary supply schedules. These factors are slow-downs, conversions to day cargo vessels, extended repairs, and, most important of all, tie-ups.

1. Slow-Downs

It is a little odd and rather unfortunate that the economics of slow-downs (and of course speed-ups when rates are high) have not been empirically determined. In the naval architecture and marine engineering literature, we read that the shaft-horse-power (SHP.) and fuel consumption vary proportionately with speed to the nth power. This "n" at "cruising speeds" is equal to three, and at maximum speed equal to four, according to Manning.  

Not being qualified on matters of marine engineering, we shall not delve into the engineering aspects of speed but will point out their economic significance by making use of the relationships between speed and fuel consumption derived by marine engineering. 2 The main purpose in slowing down a vessel is to save fuel, but capacity is lost in the process. It is necessary, therefore, to balance the cost of such loss of capacity against the savings from fuel. Immediately it is evident that fuel costs will be an important factor in

---


2 On this aspect we feel that the engineers flounder as much if not more than we do on engineering aspects. See Manning, op. cit., p. 41, where he sets as the criterion of economic efficiency for operating vessels "the ratio of the relative gross revenue to that of operating cost." Also see Benford, Harry, Engineering Economy in Tanker Design, Society of Naval Architects and Marine Engineers, Paper presented at the December 1956 meeting, 93 pp., whose economic evaluation (pp. 38-48 especially) is full of such fallacies.
problems of this nature. The question now is, how does one get an index of the cost of lost capacity?

In periods of low rates one can find tonnage very easily. Conceivably, then, one can define the cost of lost capacity in terms of the amount of money that one has to pay to transport an equivalent amount of oil by hiring more vessels in the spot market. Clearly, we are discussing the case of the oil company, since for the independent who operates in the spot markets the problem is simply one of maximizing revenue per unit of time over the life of the vessel.

Let us now formalize the above arguments. Let $S$ represent the cruising speed of a vessel per hour; $M$ the round trip distance; $K$ the number of days in port per round trip; $N$ the number of trips per year; $F$ the fuel consumption in barrels or tons per day at sea; $f$ the fuel consumption per day in port. Then, on the basis of 330 operating days per year, the capacity of a vessel is $330 \times S \times 24$ miles; and the number of trips:

$$N = \frac{330 \times S \times 24}{M + 24 \times S \times K}$$

(1)

The number of steaming days $D$ is:

$$D = 330 - N \times K$$

(2)

and the yearly fuel consumption $C$ for steaming and in port:

$$C = (330 - N \times K) \times F + N \times K \times f$$

(3)

or

$$C = 330F - N \times K(F - f)$$

(4)

\[\text{Spot-market operations are necessary for this discussion because on long-term charters the charterer pays for the fuel.}\]

\[\text{About 30-35 days of repairs were considered normal in 1958-59 on foreign flag vessels. Later we will question the validity of this figure.}\]
If we now assume that $S(1-r)$, where $r$ stands for the percentage reduction in speed, there is a corresponding fuel reduction represented by $F(1-r)^n$, we can find

$$C' = 330F(1-r)^n - N' \times K \left[ F(1-r)^n - f \right]$$  \hspace{1cm} (5)

where

$$N' = \frac{330 \times S(1-r) \times 24}{M + [24 \times S(1-r) \times K]}$$  \hspace{1cm} (6)

The savings then are equal to the difference of $(C - C')$ multiplied by the cost of fuel $p$.

$$(C - C') \times p = px \left[ 330F[1 - (1-r)^n] - K \times F[N - N'(1-r)^n] + K \times f(N - N') \right]$$  \hspace{1cm} (7)

In the above expression, the first two terms on the right-hand side represent the savings due to the lower fuel consumption while steaming, and the third terms, the savings due to lower fuel consumption in port. Notice that the latter is not due to lower fuel consumption per day in port, but to fewer days in port because of fewer trips during the year. Finally, if we add to relation (7) the savings due to port charges (again because of fewer trips and hence port visits) we get:

Yearly Savings = $px \left[ 330F[1 - (1-r)^n] - K \times F[N - N'(1-r)^n] + K \times f(N - N') \right] + (N - N') \times P$  \hspace{1cm} (8)

where $P$ is the port charge per visit.

---

1 One may assume that for a few knots below normal curising speed the fuel consumption varies with the square of the speed; at around $S(1 + r)$, $F$ becomes $F(1 + r)^2$; if $r$ is small; and for positive $r$ beyond, $F$ becomes $F(1 + r)^n$, ...., $F(1 + r)^m$. 
The loss in capacity at first approximation is equal to:

\[ L = (\text{DWT.} - M - B) \times (N - N') \]  

(9)

where M stands for crew and vessel supplies and B for bunkers (vessel fuel).

Because a reduction in bunkers will allow a further increase in carrying capacity, however, relation (9) is inflated by a fraction or all of the following quantity: \( N' \times [(C/N) - (C'/N')] \). The exact nature of this quantity will depend on the refueling schedule followed by the vessel. In cases of low rates, the vessels prefer to load at the source (low cost point) all the bunkers they need for the round trip, as the loss in marginal revenue is more than offset by the decrease in fuel costs.

The above discussion leads us to a second approximation for L:

\[ L = (\text{DWT.} - M - B) \times (N - N^3) \times q \left[ (C/N) - (C'/N') \right] \]  

(10)

where q is a factor less than or equal to unity.

Knowing the savings and the loss in capacity, we can now find the upper limit that our savings will allow us to pay in order to recover such capacity. Hence, if the spot rate R is:

\[ R < \text{Relation (8) + Relation (10)} \]  

(11)

then it pays to slow down the owned vessels and acquire additional tonnage to recover the loss in capacity.\(^2\)

\[^1\] Conceivably, with longer trips M will increase, which may counterbalance part of the additional capacity gained by the reduction in bunkers. However, supplies are not as important quantitatively as bunkers. As for B it is equal to

\[ \left( \frac{330F}{N} - K(F - f) \right) \times (1.10) \], showing that the greater the distance the lower the capacity (paying cargo) of a vessel. The factor 1.10 is an approximation of the safety allowance required by law.

\[^2\] In cases of excess owned tonnage, the alternatives are to slow down or tie up. Here, however, expectations about intermediate prospects must enter; these will be discussed later. Notice that in the case of slow-downs and spot chartering the companies preserve utmost flexibility. As rates go up, they can increase the speed of their own vessels and stop chartering.
After the Suez crisis and the ensuing drop in tanker rates, many oil companies, among which were British Petroleum, Shell, and Standard Oil Company of New Jersey, slowed down their vessels to save on fuel cost. In addition, it was rumored that around the middle of 1957, British Petroleum instructed all of its vessels of 20,000 DWT and over to use the Cape route and thus save the Suez Canal tolls. For such routes, the last term on the right-hand side of relation (8) must be changed to

\[(N - N') \times (P + D)\]  \[(12)\]
to account for the canal dues.

The above formulations were used to determine the critical spot rate for the Port Arthur to New York run and the Ras Tanura to Antwerp round trip. For the latter we have also computed a variation in order to demonstrate the impact of the Suez Canal tolls.

On the basis of the data\(^1\) shown in Table 14, it seems advantageous to slow down a T-2 from 14.5 knots to 10 if the spot rate is lower than U.S.M.C. minus 58% (or $1.20 per ton delivered) and the cost of bunkers is not less than $2.65 per barrel ($17.23 per ton).\(^2\) For the Ras Tanura to Antwerp trip of 12,880 miles by way of the Suez Canal, according to Table 15, the savings in fuel costs are sufficient to permit the chartering of vessels in the spot market at rates no higher than U.S.M.C. minus 47 1/2%, or $5.72 per delivered ton of oil.

\(^1\)The operating data were provided by Mr. M. D. Cooper, President, The Marine Brokerage Company of New York.

\(^2\)One can use the relationships that we derived to determine the impact of changes in the cost of bunkers on the most efficient speed for operating tankers.
<table>
<thead>
<tr>
<th></th>
<th>Port Arthur/New York/Port Arthur</th>
<th>At 14.5 Knots</th>
<th>At 10.0 Knots</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Port Arthur/New York/Port Arthur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Days steaming per trip</td>
<td>10.6</td>
<td>15.3</td>
</tr>
<tr>
<td>3.</td>
<td>Days in port per trip</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>4.</td>
<td>Total</td>
<td>13.6</td>
<td>18.3</td>
</tr>
<tr>
<td>5.</td>
<td>Number of trips per year (330 days)</td>
<td>24.3</td>
<td>18.0</td>
</tr>
<tr>
<td>6.</td>
<td>Total number of steaming days per year</td>
<td>258.0</td>
<td>276.0</td>
</tr>
<tr>
<td>7.</td>
<td>Total number of days in port per year</td>
<td>72.0</td>
<td>54.0</td>
</tr>
<tr>
<td>8.</td>
<td>Bunkers per day steaming (bbls)</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>9.</td>
<td>Bunkers per day in port (bbls)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>10.</td>
<td>Total bunkers per year</td>
<td>84,700</td>
<td>46,700</td>
</tr>
<tr>
<td>11.</td>
<td>Capacity in barrels occupied by bunkers per trip</td>
<td>3,500</td>
<td>2,600</td>
</tr>
<tr>
<td>12.</td>
<td>Savings by reducing speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bunkers 38,000 barrels at $2.65/bbl = $100,700</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Port charges (24.3 - 18.0) × 2,200 per trip</td>
<td>13,860</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$114,560</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Loss in capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15,620 tons per trip × (24.3 - 18.0) = 98,406 tons</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less gain because of (11) above</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$900 × 18</td>
<td>(2,500)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.5</td>
<td>95,906 tons</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Equating rate 114,560/95,906 or $1.20 per ton delivered which is approximately U.S.M.C. minus 58%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source of Data: Marine Brokerage Company, Inc.
TABLE 15

Economics of Speed

Ras Tanura/Antwerp Roundtrip Through Canal

<table>
<thead>
<tr>
<th>1. Ras Tanura/Antwerp/Ras Tanura</th>
<th>At 14.5 Knots</th>
<th>At 10 Knots</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Days steaming per trip</td>
<td>37</td>
<td>54</td>
</tr>
<tr>
<td>3. Days in port per trip plus 2 for Canal</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>4. Total</td>
<td>42</td>
<td>59</td>
</tr>
<tr>
<td>5. Number of trips per year (329 days)</td>
<td>7.86</td>
<td>5.60</td>
</tr>
<tr>
<td>6. Total number of steaming days per year</td>
<td>290</td>
<td>301</td>
</tr>
<tr>
<td>7. Total number of days in port per year and Canal per year</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>8. Bunkers per day steaming (bbls)</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>9. Bunkers per day in port and Canal (bbls)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>10. Total bunkers per year</td>
<td>90,900</td>
<td>47,950</td>
</tr>
<tr>
<td>11. Capacity in barrels occupied by bunkers per trip</td>
<td>11,600</td>
<td>8,600</td>
</tr>
</tbody>
</table>

12. **Savings by reducing speed (assume bunkers loaded at half points)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunkers</td>
<td>42,950 barrels or 6,600 tons</td>
</tr>
<tr>
<td>Ras Tanura</td>
<td>3,300 at $18.40 = $ 61,000</td>
</tr>
<tr>
<td>Antwerp</td>
<td>3,300 at $26.25 = 87,000</td>
</tr>
<tr>
<td>Total for bunkers</td>
<td>$148,000</td>
</tr>
<tr>
<td>Port charges</td>
<td>(7.86 - 5.60) × $3,500 = 7,830</td>
</tr>
<tr>
<td>Canal tolls</td>
<td>(7.86 - 5.60) × $13,200 = 29,832</td>
</tr>
<tr>
<td></td>
<td>$185,662</td>
</tr>
</tbody>
</table>
TABLE 15 Continued)

13. **Loss in capacity**
   
   \[
   15,300 \text{ tons/trip} \times 2.26 = 34,578
   \]
   
   Less gain because of (11) above
   
   \[
   \frac{3,000 \times 5.6}{6.5} + 2 = \left(\frac{1,215}{32,363}\right)
   \]

14. Equating rate $185,662/32,363$ or $5.72/\text{ton delivered}$ which is approximately U.S.M.C. minus 47.5%.

12'. **Savings by reducing speed if all bunkers are loaded at point of minimum bunker cost.**

\[
\begin{align*}
\text{Bunkers} & \quad 6,600 \text{ tons} \times 18.40 = 122,000 \\
\text{Port charges and canal tolls} & \quad 37,662 \\
\text{Total} & \quad 159,662
\end{align*}
\]

13'. **Capacity lost**

\[
14,400 \text{ tons per trip} \times 2.26 = 32,544
\]

Less: gain because of (11) above

\[
\frac{3,000 \times 5.6}{6.5} = \left(\frac{2,430}{30,114}\right)
\]

14'. Equating rate $159,622/30,114$ or $5.30 \text{ per ton delivered}$ (U.S.M.C. minus 51.5%).
These figures are on the assumption that half of the bunkers are bought at Ras Tanura at $18.40 per ton and the other half at Antwerp at $26.25 per ton.

If all the bunkers are loaded at Ras Tanura where the cost is lower, then the savings due to the differential fuel oil consumption decrease; however, capacity also decreases because of the displacement of paying cargo by the additional bunkers. These substitutions change the critical spot rate to $5.30 per ton of crude oil delivered, or U.S.M.C. minus 51 1/2%, thus further illustrating the impact of bunker prices on slow-downs, especially on long routes.

Finally, Table 16 presents the impact of the Suez Canal tolls on transportation under depressed tanker market conditions. It shows that the Cape Route would be justified only if the rate is lower than U.S.M.C. minus 70.6% ($3.20 per ton delivered), assuming bunker prices of $18.40 and $26.25 at Ras Tanura and Antwerp, respectively. If all the bunkers are loaded at Ras Tanura, the critical spot rate further drops to U.S.M.C. minus 71.6%, or $3.10 per ton of oil delivered. The evidence demonstrates that the Suez waterway is the most economical route for the vessel that can traverse it, even under excessively depressed market conditions.

Slow-downs have not actually affected tankship capacity by between 25% and 27%, as one might calculate from the data presented in the exhibits. The reason is that the low spot rates were caused by excess tonnage in the possession of the charterers in the first place, and under such circumstances the alternatives

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1. The comparisons shown in Tables 15 and 16 refer to vessels that can go through the Suez Canal loaded, i.e., 42,000 DWT. and below. For the mammoth tankers the comparison will be similar to that carried in Table 14.
TABLE 16

**Economics of Speed and Suez Tolls**

Ras Tanura/Antwerp Roundtrip Through Canal at 14.5 Knots and Around Cape

At 10 Knots

1. Ras Tanura/Antwerp/Ras Tanura around Cape both ways 22,540 miles
2. Ras Tanura/Antwerp/Ras Tanura through Suez both ways 12,880 miles

<table>
<thead>
<tr>
<th>At 14.5 Knots</th>
<th>At 10 Knots</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Days steaming per trip</td>
<td>37.0</td>
</tr>
<tr>
<td>4. Days in port plus 2 days for the Canal transit</td>
<td>5.0</td>
</tr>
<tr>
<td>5. Total</td>
<td>42</td>
</tr>
<tr>
<td>6. Number of trips per year (329 days)</td>
<td>7.86</td>
</tr>
<tr>
<td>7. Total number of steaming days per year</td>
<td>290</td>
</tr>
<tr>
<td>8. Total number of days in port and canal per year</td>
<td>39</td>
</tr>
<tr>
<td>9. Bunkers per day, steaming (bbls)</td>
<td>300</td>
</tr>
<tr>
<td>10. Bunkers per day, in port and canal</td>
<td>100</td>
</tr>
<tr>
<td>11. Total bunker per year (in barrels)</td>
<td>90,900</td>
</tr>
<tr>
<td>12. Capacity in barrels occupied by bunkers per trip</td>
<td>11,600</td>
</tr>
<tr>
<td>13. <strong>Savings by reducing speed (bunkers loaded at half points)</strong></td>
<td></td>
</tr>
<tr>
<td>Bunkers 42,060 barrels or 6,500 tons approximately</td>
<td></td>
</tr>
<tr>
<td>Ras Tanura</td>
<td>3,250 at $18.40</td>
</tr>
<tr>
<td>Antwerp</td>
<td>3,250 at $26.25</td>
</tr>
<tr>
<td>Total for bunkers</td>
<td>$145,110</td>
</tr>
<tr>
<td>Port charges (7.86 - 3.4) × $3,500</td>
<td>15,610</td>
</tr>
<tr>
<td>Canal tolls (7.86 - 3.4) × $13,200</td>
<td>58,872</td>
</tr>
<tr>
<td>Total savings</td>
<td>$219,592</td>
</tr>
</tbody>
</table>
14. Loss in capacity in tons

\[ 15,300 \text{ tons per trip} \times 4.46 = 68,238 \]

Plus loss because of (12) above

\[ 732 \]

68,970 tons

15. Equating rate \( \frac{219,592}{68,970} \) or \( \frac{3.20}{\text{ton delivered}} \)

(U.S.M.C. minus 70.6%)

13°. Saving by reducing speed if all bunkers are loaded at the point of minimum bunker cost

Bunkers \( 6,500 \times 18.40 \) = \$119,600

Port charges and canal toils \[ \frac{74,482}{\text{732}} \]

Total savings \[ \frac{194,082}{\text{732}} \]

14°. Capacity lost

\[ 14,400 \text{ tons per trip} \times 4.26 = 61,344 \text{ tons} \]

Plus loss because of (12) above \[ \frac{1,464}{\text{732}} \]

Total loss in tons \[ \frac{62,808}{\text{732}} \]

15°. Equating rate \( \frac{194,082}{62,808} \) or \( \frac{3.10}{\text{ton delivered}} \)

(U.S.M.C. minus 71.6%)

Source of Data: Marine Brokerage Company, Inc.
confronting the oil companies are slowing down their vessels or tying them up. If the outlook for depressed rates covers an extended time period, then it will be more economical for the operators to lay up their vessels and thus save wages and subsistence costs. What is more, it is doubtful whether many operators have considered the economics of speed, although at the rates prevailing since April 1957, they would have been wise to do so. The operators may appear irrational in neglecting the economics of speed while at the same time worrying about size, but there are reasons for this asymmetry. Size comparison and related decisions are ad hoc decisions made only once over the life of a vessel. In contrast, speed calculations must be made continuously because, as we have seen, they are a function of distance, spot rates, and bunker prices, among other factors. For this reason, the operators may be reluctant to reconsider the matter of speed often.\(^1\)

It is believed that slow-downs affect only an insignificant part of the total fleet and that for all practical purposes their impact on total capacity may not be greater than that of frictional unemployment. The Transportation Coordination Department of the Standard Oil Company of New Jersey has estimated that the impact of these slow-downs has resulted in what they call a "hidden surplus" of about 5% of the operating fleet.\(^2\) Although the supply schedule has,

---

\(^1\) The majority of large operators (especially the oil companies) have electronic data processing installations. Consequently, a simple program can take care of such calculations whenever necessary.

\(^2\) We believe that slow downs should have caused a much greater impact on the operating fleet. Since this phenomena occurs at a time when the relevant supply schedule is almost horizontal, because of the excessive surplus, its impact on rates will be transitory.
on the surface, remained unchanged as a result of these slow-downs, the demand schedule was effectively shifted to the right. The result has been an apparent but inflated growth in the operating petroleum fleet of the world of 9.9% in 1957 and approximately 6% in 1958. As the rates increase, this "hidden surplus" will be eliminated, thus causing leftward shifts in demand and arresting the recovery of rates. In the meantime, some owners, encouraged by the temporary recovery of rates, may put tie-ups into operation, further depressing the rates, causing slow-downs again, and so on until the whole fleet returns to operation at full capacity. These short-term dynamic (circular) considerations will cause rate fluctuations under depressed conditions, but such fluctuations are expected to be confined within very narrow limits because of the quick response from the operatives.

2. Conversions

The conversions are quantitatively insignificant. Because the tankers are extremely specialized vessels, the cost of conversion is relatively high. Only under very remunerative conditions in other markets such as grain, ore, and molasses will transfers occur, and even in those cases only the smallest and most uneconomic vessels will be normally lost to other types of trade. This is clearly shown in the data presented below. Moreover, a loss of an average of fifteen T-2's per year from a market of over 3,000 T-2's is quite unimportant.

---

1 Whether the manifestation of an impact appears as a shift in demand instead of supply, and vice versa, makes little difference. Because of the operations of the oil companies, some people may even consider the acquisition of company vessels as causing leftward shifts in demand rather than rightward shifts in supply.
Conversions

<table>
<thead>
<tr>
<th>Year</th>
<th>No.</th>
<th>T-2 Equivalent</th>
<th>Average Size in T-2 Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954</td>
<td>22</td>
<td>10.4</td>
<td>.46</td>
</tr>
<tr>
<td>1955</td>
<td>47</td>
<td>29.8</td>
<td>.63</td>
</tr>
<tr>
<td>1956</td>
<td>26</td>
<td>18.0</td>
<td>.69</td>
</tr>
<tr>
<td>1957</td>
<td>6</td>
<td>3.3</td>
<td>.55</td>
</tr>
</tbody>
</table>

3 Repairs

Finally, we come to the extended repairs and the tie-ups. According to the experts, the average duration of the yearly repairs is 25 to 30 days for vessels using United States repair yards, and 35 to 40 days for vessels using foreign yards. It appears that the difference between the average repair periods is primarily due to variations in productivity rather than to the type of repairs performed. These figures, if accurate, will place the over-all average around 35 days because the majority of vessels use European and other foreign yards.

The aforementioned figures were provided by people connected with the oil companies and may be somewhat inflated if based only on their own experience. The oil companies are known to be usually more meticulous, but in our opinion many of the independents save on idle repair time (off hire) not through carelessness, but mainly as a result of considerable preparatory as well as ancillary work performed by the crew while the vessel is on hire at ports. Characteristic are two statements, one made by the president of the tankship subsidiary of a large oil company in which he expressed satisfaction at having his vessels operate 329 days a year on the average, while his counterpart in an independent company stated that if the average idleness of his vessels because of repairs exceeded fifteen days per year, he felt that they were not doing so well.
If we accept a mean value of, let us say, 35 days around which the duration of repairs is normally distributed, we will find the probability very small indeed that repairs will stretch over 60 days. Table 17, however, shows that the capacity of vessels under repairs more than sixty days sometimes even exceeds that of the vessels under repairs between thirty and sixty days. This fact may indicate that repairs are extended during periods of uncertainty and thus serve as an intermediary step to lay-up.

In general, we can say that the level of repairs, expressed as a percentage of the operating fleet including vessels under repairs, depends upon:

1. The efficiency or technology of repair yards, and
2. The spot rate existing at the time.

Developments in the technology of ship repairing will reduce the average time required for yearly repairs, thus causing a downward trend in capacity lost. As for the spot rate, it will, we believe, affect the level of repairs by inducing ship owners to postpone, hasten, or prolong repairs. If the rates are high, the owners especially the oil companies, will even be willing to pay overtime in order to have the repairs finished early. The opposite will occur in the case of the independents if their expectations are elastic. Under declining rates, the owners who have excess capacity will at first attempt to perform any necessary repairs while waiting for the rates to improve. If the rates improve and employment is secured, repairs are finished and the vessels go into operation; but if the rates continue to be low, the repairs are extended

---

1 The distribution is expected to be skewed because the age and size of the existing fleet are not normally distributed.
TABLE 17

Repairs and Tie-Ups--Capacity Lost in T-2 Equivalents

<table>
<thead>
<tr>
<th></th>
<th>Under 30</th>
<th>30-60</th>
<th>Over 60</th>
<th>Tie Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>Days</td>
<td>Days</td>
<td></td>
</tr>
<tr>
<td>January 1, 1955</td>
<td>30.0</td>
<td>25.5</td>
<td>72.2</td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>30.0</td>
<td>30.2</td>
<td>59.3</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>26.9</td>
<td>35.4</td>
<td>54.0</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>50.8</td>
<td>26.8</td>
<td>55.8</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>78.5</td>
<td>30.5</td>
<td>55.4</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>81.7</td>
<td>34.9</td>
<td>59.9</td>
<td></td>
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<tr>
<td>July</td>
<td>69.8</td>
<td>55.8</td>
<td>57.0</td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>65.1</td>
<td>65.3</td>
<td>49.5</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>56.8</td>
<td>71.8</td>
<td>43.8</td>
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</tr>
<tr>
<td>October</td>
<td>46.4</td>
<td>66.6</td>
<td>36.0</td>
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<td>November</td>
<td>45.4</td>
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</tr>
<tr>
<td>December</td>
<td>45.6</td>
<td>43.6</td>
<td>21.5</td>
<td></td>
</tr>
</tbody>
</table>

Yearly Average: T-2s
Per Cent of Total Operating Capacity
2.4% 2.1%

<table>
<thead>
<tr>
<th></th>
<th>Under 30</th>
<th>30-60</th>
<th>Over 60</th>
<th>Tie Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>Days</td>
<td>Days</td>
<td></td>
</tr>
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<td>17.0</td>
<td></td>
</tr>
<tr>
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<td>44.7</td>
<td>31.2</td>
<td>14.4</td>
<td></td>
</tr>
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<td>March</td>
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<td>88.3</td>
<td>32.3</td>
<td>9.9</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>65.0</td>
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<td>8.7</td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>71.7</td>
<td>43.3</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>77.2</td>
<td>41.5</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>84.0</td>
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<td>October</td>
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<td>November</td>
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</tr>
<tr>
<td>December</td>
<td>33.6</td>
<td>40.8</td>
<td>4.6</td>
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</table>

Yearly Average: T-2s
Per Cent of Total Operating Capacity
2.85% 1.7%
TABLE 17 (Continued)

<table>
<thead>
<tr>
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<th>Under 30</th>
<th>30-60</th>
<th>Over 60</th>
<th>Tie Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>Days</td>
<td>Days</td>
<td></td>
</tr>
<tr>
<td>January 1, 1957</td>
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<td></td>
</tr>
<tr>
<td>February</td>
<td>48.2</td>
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<td>0.8</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>39.8</td>
<td>24.9</td>
<td>0.1</td>
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<td>71.3</td>
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<td>4.1</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>100.4</td>
<td>46.0</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>96.1</td>
<td>43.4</td>
<td>21.6</td>
<td></td>
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<tr>
<td>August</td>
<td>88.6</td>
<td>50.0</td>
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<td></td>
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<tr>
<td>September</td>
<td>115.0</td>
<td>41.3</td>
<td>64.6</td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>102.9</td>
<td>45.0</td>
<td>88.8</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>86.8</td>
<td>37.3</td>
<td>109.1</td>
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</tr>
<tr>
<td>December</td>
<td>63.9</td>
<td>33.1</td>
<td>124.8</td>
<td></td>
</tr>
</tbody>
</table>

Yearly Average: T-2s
Per Cent of Total Operating Capacity

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1, 1958</td>
<td>70.1</td>
<td>48.9</td>
<td>24.8</td>
</tr>
<tr>
<td>February</td>
<td>77.6</td>
<td>49.0</td>
<td>19.4</td>
</tr>
<tr>
<td>March</td>
<td>68.3</td>
<td>52.4</td>
<td>17.0</td>
</tr>
<tr>
<td>April</td>
<td>67.0</td>
<td>68.1</td>
<td>12.6</td>
</tr>
<tr>
<td>May</td>
<td>77.6</td>
<td>87.3</td>
<td>10.1</td>
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<tr>
<td>June</td>
<td>102.2</td>
<td>74.6</td>
<td>12.7</td>
</tr>
<tr>
<td>July</td>
<td>94.2</td>
<td>73.9</td>
<td>15.8</td>
</tr>
<tr>
<td>August</td>
<td>92.4</td>
<td>81.8</td>
<td>16.7</td>
</tr>
<tr>
<td>September</td>
<td>107.4</td>
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<td>October</td>
<td>100.6</td>
<td>69.6</td>
<td>21.3</td>
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<td>November</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Yearly Average: T-2s
Per Cent of Total Operating Capacity

Source of Data: Transportation Co-ordination Department, Standard Oil Company, New Jersey
as long as hope for a reversal exists. Once such hope is lost, the vessels are tied up. ¹

The above arguments do not apply in the case of vessels under long-term contractual agreements. Such contracts provide that the "owners undertake that nine months after the vessel was last dry-docked and at the expiry thereafter of each nine months of continuous use under the charter they will put the vessel in drydock and clean and paint her bottom at their expense as soon... thereafter as Charterers place the vessel at Owners' disposal..." ² It is natural for the charterers to prolong the nine-month period if employment exists, but to take advantage of the above provision exactly at the end of the nine months if the ships are idle, because the time taken for repairs is "off hire," and added on to the end of the period covered by the contract. At most, then, the rates will normally affect the incidence but not the duration of repairs of vessels chartered on long term. ³

The incidence of repairs is also affected by seasonal fluctuations in the trade. The late fall and the winter months being the busiest, for fuel oil

¹Tieing up vessels is rather costly, and many of the costs, such as preparatory repairs and "bottom" painting, launches, rental of river or other basins, do not vary proportionately with the number of days the vessels are tied up. Statistics on costs of lay-up are very spotty, and even those who are in a position to know profess ignorance. Figures were given--for a year's tie-up and reactivation--ranging from $20,000 per vessel to $350,000. The U.S. Maritime Administration spent $380,000 per vessel for activating eight T-2s during the fall of 1956, but these vessels were in permanent lay-up for at least three years before activation. According to the same source, reactivation costs without repairs are estimated at $60,000 per T-2. We will return to the cost of tie-up later.

²J. Bes, Tanker Chartering and Management, Amsterdam, 1956, p. 113.

³There is the case of an oil company which in late 1956 asked the owner of some of the vessels it operated under charter to forego "off hire" repairs and continue the vessels on charter pay. Necessary repairs were performed during port calls and dry-docking was postponed.
and spring gasoline stock-up, and the summer months the least busy, repairs are scheduled for the summer and early fall. Hence, in periods of low rates and in the summer, the number of repairs is expected to increase and, conversely, to reach the bottom during periods of high rates and during the winter months of each year.

In summary, we would expect to find that technology and spot rates affect the level of repairs. The impact of technology will cover the total fleet, but the spot rates will affect the duration of repairs of the oil company vessels and those of the independents trading in the spot market. The spot rate will also affect the incidence of repairs, but not the duration, for vessels on long-term charter, as will the seasonality of demand. We do, however, expect the seasonality in demand to affect the spot rate, with the result that one may not be able to distinguish very clearly between these two impacts. It may also be very difficult to distinguish the impact of spot rates on the level (duration) from that on the incidence of repairs.

To prove our contentions, we must have information on the distribution of vessels by repair intervals. Unfortunately, however, there are no data indicating the percentages of the total fleet (in T-2 equivalents) that usually completes the yearly repairs in less than 30 days, between 30 and 60 days, and finally over 60 days. The only consistent information available for the total period 1949-1958 is in terms of capacity idling over 30 days for either repairs or tie-ups. By subtracting the known tie-ups one can determine the total capacity idle for repairs extending over 30 days. But this is not sufficient, because as we have previously mentioned, the idle capacity because of repairs requiring less than 30 days is thus included in the "working petroleum fleet." Since we
have information only for 1958 concerning repairs of 30 days and under, we will use the 1958 data in our attempts to resolve the issues confronting us.

U. S. Maritime Administration data show that approximately 50% of all capacity lost in 1958 was for repairs of less than 30 days, 40% for repairs of between 30 and 60 days, and 10% for repairs extending beyond 60 days. If we now assume that vessel sizes are uniformly distributed between the repair intervals, the relationships between total capacity repairing under 30 days, between 30 and 60 days, and over 60 days must be proportional to 50:20:2.5, or 69.05% of total versus 27.5% versus 3.45%. Multiplying these percentages by mid-values of 20, 45, and 75 days, we arrive at an estimated average repair period of 28.6 days, which seems to be more realistic than that assumed by the oil companies. If we assume a mid-value of 15 for the first interval, the average repair period becomes 25.2 days per year.

For the year 1958 itself, we have all the information available and can check directly. The data of Table 17 show:

<table>
<thead>
<tr>
<th>Repair Interval</th>
<th>% of Yearly Capacity Lost</th>
<th>Average Days Per Year for Fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 30 days</td>
<td>3.35</td>
<td>12.2</td>
</tr>
<tr>
<td>30-60 days</td>
<td>2.64</td>
<td>9.6</td>
</tr>
<tr>
<td>Over 60 days</td>
<td>0.66</td>
<td>2.4</td>
</tr>
<tr>
<td>Total</td>
<td>6.65</td>
<td>24.2</td>
</tr>
</tbody>
</table>

1. We may be assuming too much here, because the newer vessels require fewer repairs and the largest vessels are the newest. However, the duration of repairs and size are positively correlated even if not directly proportional. Inasmuch as these two factors offset each other, our assumption will not falsify reality.

2. The mid-value here is intentionally increased because for all practical purposes no vessel is expected to spend less than 10 days for repairs. One case of eight days is known by the industry, and this occurred at the height of the Suez crisis. The fact, however, that the range is confined between ten and thirty days does not necessarily preclude skewness in the distribution within the interval.
An average, then, of 24.2 days of each vessel's yearly capacity was lost to repairs in 1958, which is very close to the time duration we found above by assuming uniform repair intervals. (In our subsequent discussion we shall use, whenever the calculations necessitate, 25 days as representative of the average duration for repairs for the years 1954-58.)

Of course, 1958 was a year of extensive tie-ups, or a period of "certainty" as far as the future was concerned, which may mean that some owners chose not to repair their vessels before tie-up. To the extent, however, that our percentages are in terms of non-tied-up capacity, this discrepancy is for the most part corrected. Furthermore, not many operators will neglect the necessary repairs of their vessels, because such negligence will more than catch up with them when the vessel is once more readied for operation. It is expected, nevertheless, that the decision to tie up will affect repairs of over 30-days' duration by eliminating all repairs in lieu of tie-up and possibly cutting down some repairs of over 30 days that are necessary only for vessels expected to be in operation.

Table 18 shows that the percentage of the non-tied-up fleet capacity lost because of repairs extending over 30 days is definitely, but not uniformly, declining. We chose here to show yearly data so that we might overcome the impact of seasonal periodicity, which undoubtedly must affect repairs, in the oil trade. There is some evidence that repairs are "inflated" during some years, especially the years immediately preceding those of extensive tie-ups, but the evidence that this is due to procrastination of the tie-ups is inconclusive. It may be that the post-Korean-War trend toward lower figures indicates more efficient utilization of repair time, and the year-to-year variability may be
<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity Lost Due to Repairs of Over 30 Days in T-2 Equiv.</th>
<th>Percent of Non-Tied-Up Fleet Capacity</th>
<th>Average Number of Days Capacity Lost for Repairs of Over 30 Days</th>
<th>Tie-Ups Yearly Average as % of Total Fleet</th>
<th>Ave. Rate per 1000 Ton-Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>116.9</td>
<td>10.6</td>
<td>38.6</td>
<td>3</td>
<td>1.12</td>
</tr>
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<td>1950</td>
<td>76.6</td>
<td>6.2</td>
<td>22.6</td>
<td>1</td>
<td>1.52</td>
</tr>
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<td>1951</td>
<td>69.5</td>
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<td>18.6</td>
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<tr>
<td>1952</td>
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<td>0</td>
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</tr>
<tr>
<td>1953</td>
<td>65.8</td>
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<td>15.7</td>
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<td>.94</td>
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<td>15.0</td>
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<tr>
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<td>97.3</td>
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<td>2</td>
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<td>1956</td>
<td>101.6</td>
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<td>16.8</td>
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<td>17.2</td>
<td>1</td>
<td>1.52</td>
</tr>
<tr>
<td>1958</td>
<td>84.4</td>
<td>3.3</td>
<td>12.0</td>
<td>9</td>
<td>.68</td>
</tr>
</tbody>
</table>

Source: Transportation Co-ordination Department, Standard Oil Company, New Jersey. Rates as in Table 12
indicative only of "ability to pay" for repairs. Whatever the reason, the difference between the capacity lost in 1949 and that lost in 1958 is quite significant, especially for long run supply schedules as inelastic as those of tankers.

Because we are dealing with movements that are affected by time lags, expectation, costs, and many qualitative factors, we cannot rely on yearly data alone for our analysis of repair data, but must also look into monthly movements. Figure 22 shows the plot of repairs of 30 to 60 days, 60 days and over, tie-ups, and (for 1958) repairs of under 30 days. We observe in this table a consistent trend toward lower capacity losses because of repairs extending over 60 days, which may be the result of efficiency; but except for this and a possible upward trend in repairs of 30 to 60 days, the data do not help us in any conclusive way. The upward trend in repairs of 30 to 60 days is possibly due to "repairs in lieu of tie-up," because it occurs in the middle part of 1957 just before extensive tie-ups take place. Note how later on in 1957 the repairs of 30 to 60 days and especially those of over 60 days decrease extensively as tie-ups increase. The peak reached in June 1955 may be due to a combination of (a) vessels deactivated (note that the tie-ups decrease substantially) and (b) seasonal repairs.

To study the movements in total idle capacity and to observe the impact of seasonal trade on repairs, we now turn to Figure 23. The term "idle" appearing here indicates all capacity idle for 30 or more days for repair and tie-up. It is evident from the exhibit that the level of repairs is not constant and that it is affected by rates. The presence of technological impacts, even though not very vivid, can be inferred from the levels reached by the idle fleet
during the two periods of record rates, namely the Korean conflict and the Suez crisis. Although the lowest point reached during the former period was 3.2% of the total fleet, during the Suez crisis the corresponding figure was 2.4%. As we have seen in Table 18, there is a definite downward trend in the percentage of capacity idle due to repairs of over 30 days. Even if we assume that changes in technology--or imitation by some countries of the technology of others--affect chiefly the longer repairs, the observed trend will also be present in the total sum of all repairs.

Figure 23 further shows that within any one year there exists a periodicity in idle capacity, and gives evidence that this periodicity can be attributed to repairs regardless of movements in tie-ups. It is also evident that the short-term rate affects such periodicity. Also, to the extent that the rate movements lead those of idle capacity, we may conclude that the pattern observed in idle capacity is due to shifts in demand rather than to anticipations operating on the supply side. Such seasonal shifts in demand are expected and discounted by those operating in the tankship markets, and thus future expectations are not altered unless a deviation from the usual pattern occurs. Hence, the seasonal fluctuations in idle capacity because of repairs are equilibrating.

In summary, the incidence as well as the level of repairs is expected to vary with the spot rates. During periods of low rates, repairs are extended, as long as uncertainty prevails. Once the near-future course of rates becomes clear, however, vessels are taken away from "extended repairs" and led to tie-up. That is why repairs tend to decrease once tie-ups start rising. The extent to which necessary repairs are inflated by extended repairs does not in our estimation exceed 1 1/2% of the non-tied-up capacity. A regular periodicity in
repairs due to the seasonality of trade is observed, but both this variation and the impact of extended repairs seem to be equilibrating. Finally, the level of repairs seems to be affected also by the state of technology in ship repairing, as evidenced by the downward post-war trend in the average duration of repairs extending over 30 days.

4. Tie-Ups

We have previously pointed out that during periods of low rates and uncertainty, the vessel owners will attempt to keep their vessels afloat in the hope of finding remunerative employment for them. As long as this surplus tonnage is competing in the market, however, hopes for improvement in rates cannot materialize. Naturally, each owner hopes that all the others will tie up their vessels first; but as soon as some major owner loses hope and starts extensive tie-ups, all the rest take this as an indication of extended depression and, paradoxically, do likewise, even though they originally started with a "let someone else do it" attitude.

Before the stage of tie-ups, and while their expectations are inelastic, the owners as a first measure attempt some slow-downs and extended repairs until there is no doubt in their minds about the immediate future. During this period of uncertainty, the spot rates settle not at the normal average variable cost of operation, but even lower. Any owner who foresees a period of unemployment—if he insists on a rate that covers normal average variable costs—will undoubtedly adjust his refusal rate to reflect the average out-of-pocket idle costs over such a period of would-be idleness.
There are two types of potential idle costs: costs due to idleness in a state of operational readiness, and lay-up cost. The owners will stay in operational readiness only if employment is foreseen in the immediate future or if the tie-up costs are greater than the costs of idleness in operational readiness.

Clearly, an assumption that the cost of tie-up is greater than the cost of idleness in operational readiness, if correct, would imply negative rates and zero tie-ups. We can therefore dismiss it outright. We do expect, however, to find operators accepting any short-term rate that is greater than the variable operating cost minus the average out-of-pocket idle cost per unit of capacity involved.

In our attempts to collect data on tie-up costs, we were confronted with a very confusing array of irreconcilable figures. Many sources did not explain--presumably did not really know--the components of the figures they quoted. Such figures, therefore, could not be used at all. Only the tanker brokers\(^1\) seemed to possess detailed data, and it is on their figures (after separating those relevant for economic decision making) that we shall base the following discussion.

The key role in our exposition inevitably will go to the marginal vessel. The out-of-pocket operating costs of such a vessel will be vital, because these costs enter into the determination of the point at which withdrawal from the market occurs. Besides, it is the operating cost of the marginal vessel that

\(^1\)Mainly Marine Brokerage Co., Inc. and, to a lesser degree, Cosmopolitan Transit Lines, both of New York.
determines the upper limit, and hence the going rate in the market under conditions of firm (full-capacity) demand.

Now what are the characteristics of this marginal vessel? Does it have to be the smallest vessel in operation? In theory it may, but not in practice, because there is no recontracting and no single market. For this reason the marginal unit for empirical research purposes must be important in terms of capacity. If not, its impact will be at most of a fleeting nature, not lasting long enough to be observed.

Luckily we do have such a unit in the tankship markets, the war-built T-2. Inasmuch as approximately 13% of total fleet capacity in 1959 is accounted for by such vessels, there is no doubt as to their importance in rate determination. In markets where the short-term supply schedules are as inelastic as those of tankships, the marginal unit is expected to define the range of the turning points; and because of its significant contribution to capacity, it will undoubtedly be found to play a very important part in defining also the lower limit of the rates.

It is evident that the smallest unemployed unit will be the first to withdraw from the market. Although with the existence of long-term contracts not all of the smallest vessels will be the first out of employment, certainly the smallest of the unemployed vessels will be laid up first. This much is indicated by Table 19 which traces the monthly developments in 1958. The average size of the vessels tied up increased steadily up to June; but then, with the withdrawal from tie-up of the larger vessels, the average size dropped gradually from .95 T-2s to .82.
The marginal size of the vessels tied up presents an even better picture of how the sizes respond to rates and expectations. Up to June 1958, the vessels in tie-up were increasing, and the average size of tankers tied up increased from .93 to 2.20 T-2 equivalents in just four months. Then, with the seasonal repair absorbing some capacity, the short-term rates responded, causing a change in the expectations of some owners, who thought that this was a sign of revival and consequently reactivated their vessels. Unfortunately, the owners seemed to react faster to increases in rates, and to adopt a "wait and see" attitude on decreases. The reactivation, of course, created surplus tonnage in operating readiness, which pushed the rates from their best level for the year of 84 cents down to 66 cents per 1,000 ton-miles.

The size of the vessels reactivated does not present any consistent pattern, with the exception that all these vessels are larger than a T-2. This may indicate that expectations were mixed among the owners of laid-up capacity, who reacted in different ways.

We have previously noticed in exhibits such as Figure 23 that tie-ups lag behind the rate movement during the downturn by several months. This reluctance is admittedly due in part to the uncertainty that sudden changes produce, but it also involves some practical economic considerations. We refer specifically to the cost of tie-ups.

As Table 20 shows, the greatest part of the tie-up cost is a fixed outlay of approximately $20,000. Depending on the distance between loading and unloading points this is equivalent to 39-43 cents per 1,000 ton-miles, or between 23.2 and 27.3 U.S.M.C. points, if the tie-up period extends for only one month. Many owners may be tempted, as a result, to undercut the going
TABLE 19
Average Size of Laid-up Vessels

<table>
<thead>
<tr>
<th>Date</th>
<th>Average Size of All Tied-up Vessels in T-2 Equivalents</th>
<th>Rate per 1,000 Ton-Miles</th>
<th>Average Size of Vessels Tied-up during Month or (Withdrawn) from Tie-up</th>
<th>Adjusted for Vessels Withdrawn and Scrapped</th>
<th>Average Size of Ships Scrapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-58</td>
<td>.70</td>
<td>63</td>
<td>.93</td>
<td>.93</td>
<td>None</td>
</tr>
<tr>
<td>2-58</td>
<td>N.A.</td>
<td>67</td>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>3-58</td>
<td>.86</td>
<td>62</td>
<td>.93</td>
<td>.93</td>
<td>None</td>
</tr>
<tr>
<td>4-58</td>
<td>.88</td>
<td>61</td>
<td>.96</td>
<td>.96</td>
<td>None</td>
</tr>
<tr>
<td>5-58</td>
<td>.91</td>
<td>61</td>
<td>1.52</td>
<td>1.52</td>
<td>.40</td>
</tr>
<tr>
<td>6-58</td>
<td>.95</td>
<td>61</td>
<td>2.20</td>
<td>2.20</td>
<td>.68</td>
</tr>
<tr>
<td>7-58</td>
<td>.90</td>
<td>65</td>
<td>(1.48)</td>
<td>(1.67)</td>
<td>.53</td>
</tr>
<tr>
<td>8-58</td>
<td>.89</td>
<td>78</td>
<td>(1.16)</td>
<td>(1.20)</td>
<td>.40</td>
</tr>
<tr>
<td>9-58</td>
<td>.85</td>
<td>84</td>
<td>(2.27)</td>
<td>(2.27)</td>
<td>None</td>
</tr>
<tr>
<td>10-58</td>
<td>.84</td>
<td>78</td>
<td>(1.06)</td>
<td>(1.06)</td>
<td>None</td>
</tr>
<tr>
<td>11-58</td>
<td>.85</td>
<td>71</td>
<td>(1.53)</td>
<td>(1.87)</td>
<td>.50</td>
</tr>
<tr>
<td>12-58</td>
<td>.82</td>
<td>66</td>
<td>(1.26)</td>
<td>(1.68)</td>
<td>.57</td>
</tr>
</tbody>
</table>

Source of Data: Transportation Co-ordination Department, Standard Oil Company, New Jersey
rate, hoping that by the time their trip ends the market conditions will be better. This, however, is a vicious circle. Once rates are cut because of surplus tonnage, there is a tendency for the same process to be repeated, because at each new round of negotiations the initial tie-up costs make the refusal rate 23 to 27 U.S.M.C. points lower than it would have been otherwise. In fact, once an owner permits himself to enter such an agreement, the probability that he will repeat it is strong. It is like waiting for a bus rather than walking to a short-distance destination. The longer one waits, the longer the temptation to continue waiting, only because he has waited that long already. Inherent in such behavior is the belief that, like the expected change in the gambler's luck, the revival of rates (the bus) will eventually arrive and the longer the period of waiting, the closer the point of reward.

The expectations of the owners who behave in the manner described in the previous paragraph are rate inelastic like those of all the other owners who may tie-up their vessels during this period of uncertainty. The difference in behavior is due to the fact that the duration of the uncertainty and unemployment is shorter in the eyes of those who stay in the market. The charters transacted at distress rates are of one voyage duration at a time and are accepted by the owners in lieu of tie-ups in the hope that market conditions will soon improve. Incidentally, once undercutting starts, there need not be many cuts before the rates reach the floor, nor does the system need many participants to operate. As long as there are just a few

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1Because rental services are perishable (cannot be stored to be sold later) and a significant amount of out-of-pocket costs is involved to stay in readiness there is a strong pressure on the owners to either accept low rates or tie up their vessels. So such a behavior is not due to elastic expectations.
<table>
<thead>
<tr>
<th>Duration of Tie-up in Months</th>
<th>Incremental Cost</th>
<th>Cumulative Total Cost in $</th>
<th>Approx. Cost in Cents per 1,000 Ton-Miles of Capacity Lost</th>
<th>Approximate U.S.M.C. Points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>P.G./U.K.</td>
<td>US.G/N.Y.</td>
</tr>
<tr>
<td>1</td>
<td>25,298</td>
<td>25,298</td>
<td>39.2</td>
<td>43.0</td>
</tr>
<tr>
<td>2</td>
<td>5,298</td>
<td>30,596</td>
<td>23.8</td>
<td>26.0</td>
</tr>
<tr>
<td>3</td>
<td>5,298</td>
<td>35,894</td>
<td>18.7</td>
<td>20.3</td>
</tr>
<tr>
<td>4</td>
<td>5,298</td>
<td>41,192</td>
<td>16.0</td>
<td>17.6</td>
</tr>
<tr>
<td>5</td>
<td>5,298</td>
<td>46,490</td>
<td>14.4</td>
<td>15.8</td>
</tr>
<tr>
<td>6</td>
<td>5,298</td>
<td>51,788</td>
<td>13.3</td>
<td>14.6</td>
</tr>
<tr>
<td>n</td>
<td>5,298</td>
<td>20,000</td>
<td>≈8.2</td>
<td>≈9.1</td>
</tr>
<tr>
<td>n x 5,298</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*At the end of the tie-up period if not before six months or at the end of a year from the last bottom painting, whichever comes first, approximately 10-12 thousand dollars are needed for painting. However, most of this cost ($10,000) would have been necessary had the vessel been in operation. In addition, a certain amount of preventive maintenance purely due to tie-up is necessary which may be done continuously or at the reactivation point. This cost is approximately $1,000 per month, minimum, and is included here.

*For n large enough the values approach these figures asymptotically.*

P.S. stands for Persian Gulf; U.K. for United Kingdom; US.G. for U.S. Gulf; N.Y. for New York

owners who are willing to remain in the market idle but in readiness, the existence of the larger vessels guarantees that market prices will eventually reach a level lower than the out-of-pocket minus the expected tie-up cost for most T-2 vessels.

It is indeed surprising, in view of the figures of Table 20 (if correct), that the owners do not withdraw their tonnage as soon as the rate falls below the out-of-pocket cost point. Why they wait months before they decide to tie up their vessels is difficult to understand. Many of the voyages undertaken during depressed periods barely yield, as we shall see shortly, over out-of-pocket minus initial tie-up cost. The reason is that the expectations of most owners about employment at remunerative rates are inadvertently spoiled by those vessels whose contractual agreements begin a month or so hence, by crew costs that some owners consider fixed or unavoidable, and by ships which are to be relocated. These latter vessels can afford to take virtually any rate as long as it is positive.

The behavior of the tanker owners and operators clearly indicates that either the data shown in Table 20 are wrong or the owners overestimate the cost of tie-ups. If the data are correct and if we may assume uncertainty over, let us say, a six-month period, no operator should accept any contracts at a rate below out-of-pocket cost less 10 U.S.M.C. points, because the average tie-up costs over a six-month period are between 8 and 9.3 U.S.M.C. points. However, many contracts for T-2s are negotiated at much lower rates.

Another possible explanation of the reluctance to tie up vessels may lie in prestige factors, hesitance to admit mistakes, and even some administrative costs of decision making (changing plans). This last,
incidentally, was found, to be a real consideration, in visits with various people in the industry. Apparently, non-routine decision-making is painful, or at least bothersome, and many people would rather forego profits than overcome their own reluctance, as well as that of their superiors, in order to act in time. This is especially true in the case of the oil companies, because of their cumbersome organizational structure.

In order to find the critical rates for the marginal vessel, we have calculated and presented in Table 21 the "break-even" point of a T-2, under foreign flag. The present cost, excluding minimum return on investment, appears to be $1.15 per 1,000 ton-miles for the Persian Gulf-Antwerp trip and $1.12 for the Maracaibo or Port Arthur/New York run. Although this cost may be the relevant one under conditions of full capacity, it is the out-of-pocket cost that determines the withdrawal of the fleet under depressed market conditions.

The costs usually avoided when the vessel is in tie-up include wages, all the relevant costs associated with the crew, and repairs and maintenance due to operations. To cover these costs, a T-2 under foreign flag and with an Italian crew must receive $5.80 per ton for the Persian Gulf/Antwerp run and $1.54 per ton delivered for the Maracaibo or Port Arthur/New York trip, that is, approximately U.S.M.C. minus 47% and U.S.M.C. minus 46%, respectively, or $.90 per 1,000 ton-miles for the Persian Gulf employment and $.89 per 1,000 ton-miles for the Western Hemisphere trade.

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1. U.S. coastal trade is restricted to U.S. flag vessels. Use of the foreign cost figures here is made only for comparative purposes.

2. The reader may remember that for the 1954-1958 period we have observed a turning point of expectations at around $1.10-1.20 per 1,000 ton-miles. See the discussion on "Spot Rates and Orders Placed--Empirical Observations."
<table>
<thead>
<tr>
<th>Item</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages (40 men)</td>
<td>$76,336</td>
</tr>
<tr>
<td>Seniority, Vacation Leave, Social Insurance</td>
<td>18,316</td>
</tr>
<tr>
<td>Overtime</td>
<td>25,225</td>
</tr>
<tr>
<td>Provisions at $1.75 per Man-Day</td>
<td>25,550</td>
</tr>
<tr>
<td>Repatriation and Manning</td>
<td>15,000</td>
</tr>
<tr>
<td>Insurance and Other Premiums</td>
<td>22,242</td>
</tr>
<tr>
<td>Stores and Expendable Equipment</td>
<td>31,025 $213,694</td>
</tr>
<tr>
<td>Repairs and Maintenance</td>
<td>100,000</td>
</tr>
<tr>
<td><strong>(1) Sub-Total</strong></td>
<td><strong>$313,694</strong></td>
</tr>
<tr>
<td><strong>Miscellaneous and Off-Hire Costs</strong></td>
<td>$10,000</td>
</tr>
<tr>
<td>Hull and Machinery Marine Insurance</td>
<td>43,316</td>
</tr>
<tr>
<td>War Risk Insurance</td>
<td>2,009</td>
</tr>
<tr>
<td><strong>Excess Liabilities Insurance</strong></td>
<td><strong>365 $55,690</strong></td>
</tr>
<tr>
<td><strong>(2) Total before Fuel, Port Charges, Tolls, Depreciation, and Overhead</strong></td>
<td>$369,384</td>
</tr>
</tbody>
</table>

**Allocated Costs**

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Overhead</td>
<td>$21,900</td>
</tr>
<tr>
<td>Depreciation (20 Years Straight Line)</td>
<td>158,400</td>
</tr>
<tr>
<td>Interest (5% on Average Investment)</td>
<td>79,200</td>
</tr>
<tr>
<td><strong>(3) Total Excluding Fuel, Port Charges, Tolls</strong></td>
<td><strong>$628,884</strong></td>
</tr>
</tbody>
</table>

**Fuel, Port Charges, Canal Tolls**

<table>
<thead>
<tr>
<th>Region</th>
<th>Persian Gulf/Antwerp</th>
<th>Maracaibo or Port Arthur/N.Y.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>$249,400</td>
<td>$224,455</td>
</tr>
<tr>
<td>Port Charges</td>
<td>27,510</td>
<td>52,000</td>
</tr>
<tr>
<td>Canal Tolls</td>
<td>103,752</td>
<td>0</td>
</tr>
<tr>
<td><strong>(4) Total</strong></td>
<td><strong>$380,662</strong></td>
<td><strong>$276,455</strong></td>
</tr>
</tbody>
</table>

**Out-of-Pocket Costs**

<table>
<thead>
<tr>
<th>Region</th>
<th>Persian Gulf/Antwerp</th>
<th>Maracaibo or Port Arthur/N.Y.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Total (1)</td>
<td>$313,694</td>
<td>$313,694</td>
</tr>
<tr>
<td>Fuel, Port Charges, Tolls (3)</td>
<td>380,662</td>
<td>276,455</td>
</tr>
<tr>
<td><strong>Total, Annual</strong></td>
<td><strong>$694,356</strong></td>
<td><strong>$590,149</strong></td>
</tr>
</tbody>
</table>

**Total Tons Delivered, Annually**

<table>
<thead>
<tr>
<th>Region</th>
<th>Persian Gulf/Antwerp</th>
<th>Maracaibo or Port Arthur/N.Y.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120,258</td>
<td>383,940</td>
</tr>
</tbody>
</table>
TABLE 21 (continued)

<table>
<thead>
<tr>
<th></th>
<th>Persian Gulf/Antwerp</th>
<th>Maracaibo or Port Arthur/N.Y.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7) (5)/(6)</td>
<td>$5.80</td>
<td>$1.54</td>
</tr>
<tr>
<td>or U.S.M.C. minus</td>
<td>47.0%</td>
<td>46.0%</td>
</tr>
<tr>
<td>or A.T.R.S. minus</td>
<td>48.4%</td>
<td>46.0%</td>
</tr>
<tr>
<td>per 1,000 Ton-Miles</td>
<td>$.90</td>
<td>$.89</td>
</tr>
<tr>
<td>(8) (3 + 4)/(6)</td>
<td>$8.43</td>
<td>$2.42</td>
</tr>
<tr>
<td>or U.S.M.C. minus</td>
<td>22.6%c</td>
<td>17.3%d</td>
</tr>
<tr>
<td>or per 1,000 Ton-Miles of Delivered Oil</td>
<td>$1.31</td>
<td>$1.28</td>
</tr>
<tr>
<td>(9) Adjustment to Bring Repairs Down to 25 Days: U.S.M.C. Points</td>
<td>1.0e</td>
<td>1.0</td>
</tr>
<tr>
<td>(10) Wages Adjustment U.S.M.C. Points</td>
<td>2.0f</td>
<td>2.3</td>
</tr>
<tr>
<td>(11) Representative Full Cost (Including Interest) Items (7), (8), (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.M.C. minus</td>
<td>25.6%</td>
<td>22.5%</td>
</tr>
<tr>
<td>per 1,000 Ton-Miles of Oil Delivered</td>
<td>$1.26</td>
<td>$1.23</td>
</tr>
<tr>
<td>(12) Representative Full Cost Excluding Interest U.S.M.C. minus</td>
<td>31.7%</td>
<td>29.8%</td>
</tr>
<tr>
<td>(13) per 1,000 Ton-Miles</td>
<td>$1.15</td>
<td>$1.12</td>
</tr>
</tbody>
</table>

---

a U.S.M.C. flat (100%) is $10.90 per ton delivered.
b U.S.M.C. flat (100%) is $2.85 per ton delivered.
c Overhead 1.7 U.S.M.C. points; Depreciation 12.3 points; Interest 6.2 points; Insurance 4.3 points.
d Overhead 2.0 U.S.M.C. points; Depreciation 14.4 points; Interest 7.2 points; Insurance 5.1 points.
e To bring the repairs down to what we found is the representative level.
f Italian wages are the second highest foreign wages. The adjustment of $25,000 per year brings wages closer to the foreign average.

Because 35-36 days' idleness for repairs seems excessive\(^1\) and because, furthermore, the wages received by Italian crews are the second highest foreign wages in the free world\(^2\), adjustments have been made to approach the median cost of a T-2. With these changes, the minimum rate required to cover the out-of-pocket costs of a T-2 is around U.S.M.C. minus 50%. This, however, is not the refusal rate, because the owners must consider the cost of tie-up. With the latter included, the theoretical lower limit of the refusal rate drops to around U.S.M.C. minus 73% for the Persian Gulf/Antwerp trip and approximately U.S. M.C. minus 77% for the Maracaibo or Port Arthur/New York trade.

One would not expect to observe average levels of this sort for an extended time period, for several reasons:

1. It does not seem logical that the owners will consider only one month's tie-up costs while negotiating for employment extending over several months. The round trip distance, for example, between the Persian Gulf and most North European countries takes about one and a half months. Furthermore, as time goes by, the owners may naturally consider a time duration beyond that of a trip.

2. The brokerage fees which are paid by the owner are approximately equivalent to 2% of the total "hire" involved.\(^3\)

3. The owner must be offered some inducement, however small, to keep in operation.

Point (1) would increase the refusal rate by at least 10 to 12 U.S.M.C. points to reflect out-of-pocket cost of operation less two months' average

\(^1\)See the discussion on "Extended Repairs."

\(^2\)French crews are the highest paid, see James V. Metcalfe, Principles of Ocean Transportation, Simmons-Boardman, New York, 1959, p. 281.

\(^3\)During depressed periods these fees may go as high as 4 1/2 percentage points because of efforts by more than one broker to secure employment for a vessel.
tie-up cost, (2) by two points, and (3) by probably 3 to 5 points. As a result, the average lower limit of the refusal rate for a T-2 would be found around U.S.M.C. minus 60% or around $.62 and $.68 per 1,000 ton-miles depending on the route.¹ This we shall call the "T-2 lay-up rate."

So much for the average. Let us again point out, however, that single transactions at lower rates (deviations from the averages) will occur because:

1. Vessels which can fit a voyage in between re-employments may be willing to accept lower rates than those specified above, because their only out-of-pocket costs under such circumstances are the cost of the fuel and the port charges. (The labor cost, which is unavoidable in cases such as this, is approximately equivalent to 16.6 U.S.M.C. points for the Persian Gulf run and 19.5 points for the U. S. trade.)²

2. Tankers on their way to a loading port or place of tie-up may accept a cargo at lower rates because in such a case their marginal cost is practically zero.

3. Many oil companies have crew employment policies such that the wages become in effect unavoidable. Whenever their surplus vessels

¹ Notice that the U.S.M.C. scales are not equalized. Thus, the use of the U.S.M.C. scales without specification of the route or conversion to 1,000 ton-miles equivalent rate is very misleading. We have seen this from the results of Table 21 where the various approximations to the full cost of a T-2 varied by as much as 5.3 U.S.M.C. percentage points. We now notice also that U.S.M.C. minus 60% will give $.62 per 1,000 ton-miles for the Maracaibo or Port Arthur/New York route but $.68 for the Persian/Gulf Antwerp run.

² Even though fixtures indicating absolute wage fixities are not very common, some transactions for T-2s were concluded in 1958 around U.S.M.C. minus 70%-75% and even some at U.S.M.C. minus 80%. See, for example, the fixtures of World Trade reported the week ending January 31, 1958, and Arabia Maru reported the week ending May 1, 1958, both fixed at U.S.M.C. minus 80% (Reported by Davies & Newman Ltd., of London.) Both these vessels were "relets," and the rate agreed indicated a complete fixity of crew costs.
appear in the market as 'relet,' therefore, they can afford to accept a lower rate than usual for the same reasons as in (1) above.\footnote{The fact that the employment policies of the oil companies lower the refusal rate explains why the oil companies when beset by excess capacity prefer to tie up vessels that they have on long-term charter and operate their own, even though the latter may be less efficient than the former. The reason, let us repeat, is that the marginal cost of the chartered vessels is higher because of the crew costs. If a chartered vessel is tied up, any savings accruing to the owner because of such tie-up are returned to the charterer. Among these savings is the cost associated with the crew. The above may be behind the difference in the average age of the tie-up fleets of the independents and the oil companies. The average age of the ships tied up in December, 1958, and belonging to the major independents was 11.0 years, while that for the oil company vessels was 14.7 years. Most of the tied-up vessels belonging to the independents were on long-term charter agreements with oil companies.}

As for the average rates in the markets, we have said that the refusal cost of the T-2s will govern, because these vessels comprise such a significant percentage of the total capacity. In general, the rates would drop below the T-2 refusal rate only if the shifts in demand to the left and/or supply to the right create surpluses greater than the total capacity of vessels of T-2 size and smaller. Sometimes, however, due to the imperfections in the spot markets created by the long-term contractual agreements,\footnote{Such imperfections allow T-2s to operate, when on long-term charter, while existing supertankers and new buildings of the super-tranker size may be seeking employment at their effective marginal cost of around U.S.M.C. minus 70\%-75\%, or even led to tie up.} many supertankers may be seeking employment at the same time and may thus force the rates temporarily to a point below the T-2 critical rate. We do expect, however, to find that, in general, the prevailing rate is based on the T-2 refusal cost, in which case it will not only cover the out-of-pocket cost of the supertankers but will also contribute toward their fixed costs.
We shall now turn to some empirical quantitative evidence on the relationship between rates and tie-ups. Even though the oil companies and the independents are motivated by somewhat different considerations in their decision to tie up vessels, this makes little difference from the practical point of view, in our estimation.

It is true that the oil companies in periods of surpluses will at first stop chartering and will tie up their own vessels or vessels chartered by them only if their transportation needs are lower than the capacity at their disposal. Thus, the factors governing company tie-ups emanate from the transportation needs of the oil companies, and not from the level of short-term rates. However, to the extent to which oil companies can place their vessels in the spot market in cases of excess capacity, if they find the rates remunerative, they will tie up vessels only under depressed rates.

Theoretically, because of the dual role of the oil companies, one may argue that the oil company tie-ups, unlike those of the independents, constitute an external factor independent of rates and are thus rate determining and not rate determined. But really what difference does it make? Is it

---

1 This is only true at the beginning of the downturn. Once the depression has set in and caused company-owned vessels to be laid up, it may be found more advantageous to enter the spot market for short-term needs than to make outlays for reactivation. That is, as long as the spot rate is lower than the out-of-pocket cost of operation to the companies plus the net reactivation cost (including the cost of all "fixities" such as extended crew commitments that are marginal with the decision less the alternative tie-up costs) averaged over such short term, the companies will cover their short-term needs through the spot market. There is ample evidence that this is being done.

2 Koopmans, Op. Cit., Section 7. He states, however, that "the conclusions drawn ... would prove to be largely independent of the hypothesis adopted ..." p. 138.
not, in the first instance, the existence of unemployed vessels that causes spot rates to drop? As previously pointed out, we are not observing only continuous movements along the supply and demand schedules in static terms; we also witness shifts in such schedules. Does it matter whether such a situation was created by curtailment of the demand resulting from the withdrawal of the oil companies from the spot market or by the failure of the demand to keep up with the new supply, or from a combination of both? Given the shape of the demand schedule (as affected by interperiod substitutions and with its "schizophrenic" tendencies at low rates) and the infinite elasticity of the short-term schedule below full capacity, it really makes no difference at all. The same results can be obtained under any hypothesis.

We have already observed, in conjunction with rates and orders placed, that in non-static terms there is a certain degree of circular interdependence between rates and the position of the demand schedule, indicating that rates do affect and are affected by shortages and surpluses. Furthermore, the spot market continues to exist, and in fact may be the only active market, under depressed conditions and the oil companies are free to enter the market with their excess tonnage. Thus, even though low rates are not a sufficient condition for company tie-ups, they are a necessary one.

The arguments presented above also apply in the case of the independents, because approximately 77% of the independent tonnage (approximately 51% of the world total) is at any moment of time operating outside the spot market

1 Under such circumstances—unless measured during periods of very swift rate movements—empirical indices of static elasticity are dangerously misleading. This is especially true in the case of demand schedules which are measured on the basis of quantities bought and sold, not demanded, at the various rates.
on long-term charters to the oil companies. The impact of these charters is no different from that of the oil company needs for tonnage. That is, some vessels may still be employed, even though the rate is below the relative normal lay-up point, merely because they are either owned or controlled through charters by oil companies. However, the emphasis on the word normal implies that these vessels will be affected also by the spot rate and that their effective lay-up point may for particular reasons be lower than that of comparable vessels in the spot market.

How then are these theoretical imperfections expected to affect the tie-up schedules? Admittedly they will introduce imperfections by causing efficient vessels to be tied up while less efficient ones operate. Such imperfections, however, will not in any essential way impair the key role of the short-term rates in determining tie-ups, for the following reasons:

1. The larger vessels that have lower normal tie-up points will be typically found on long-term charters, thus leaving the inefficient vessels in the spot market.

2. Approximately 15% of the world total capacity is operating in the spot market, and this quantity is more than enough to give us empirical evidence of the relationship between rates and tie-ups, especially since the range of the tonnage operating in the spot market varies from 20% under depressed market conditions to 8% during periods of strong demand.

There are several reasons for this: (a) the construction may have been initiated by a charter; (b) these are "specialized" vessels because of their size, and cannot be used without advance planning. As a result in order to achieve the economies of such specialization these vessels must be assigned to continuous specialized runs; (c) the opportunity cost of idleness in the case of large vessels is extensive and the owners do not wish to risk unemployment.
3. The company-owned capacity is affected by the spot rate because the spot market serves as an outlet for oil company surplus tonnage.

4. The provisions included in time charters give options to the charterers to lay up the chartered vessels, "in which case the hire provided for under this charter shall be reduced by the amount by which the Owners can reasonably reduce the expenditure otherwise falling upon them ..."\(^1\) The expenditures that can be "reasonably reduced" are the wages and other costs associated with the crew, such as subsistence, bonuses, insurance, and some vessel costs such as stores (but not fuel for the engines).\(^2\) In effect, the chartered vessels may be affected by the short-term rates as much as any other vessel, even though for different reasons. Their effective lay-up point may not be as high as that of comparable size vessels operating in the spot market, but it may be higher than that of the company-owned vessels because of the costs associated with the crew.\(^3\)

5. Because of the existence of a minimum quantity below which the demand does not fall (i.e., there exists a part of the demand schedule that is determined independently of rates, and hence it is infinitely inelastic in static terms), it is the "marginal" quantity that is of interest to us. Hence the capacity operating in the spot market will set the price.

---


3. Koopmans' analysis was based on the premise that "The reduction in these items through the laying-up of the vessel does not, therefore, enter into the charterer's calculations," which is incorrect, unless the stipulations of time charters have changed since Koopman's study, for which we have no evidence. See his *Tanker Freight Rates and Tankship Building*, p. 111.
For the reasons expressed above, no attempt will be made to separate the
tie-ups into those coming from spot-market operations versus those under the
control of the oil companies. Nor would the latter be further subdivided
into company-owned vessels and those chartered on long-term.

Figure 24 presents a scatter diagram of the vessels tied up (expressed
in T-2 equivalents) versus the spot rates by months for the years 1949 and
1958. We do notice that there is an extensive range of rates over which
tie-ups vary only slightly; then, at a rate of approximately $1.10-$1.20
per 1,000 ton-miles, withdrawals become heavier until finally the schedule
becomes completely vertical at around $.90 per 1,000 ton-miles. These
observations are in complete agreement with our expectations that we
based on purely theoretical considerations.

The quantitative relationship between tie-ups and rates is best ex-
pressed by:

\[ y \text{ (tie-ups)} = 0.1 + 41.1/X^2 \]

The correlation coefficient was found to be .78 with a coefficient of
determination of .6, which is a respectable relationship. The rate \( x \) is
expressed in dollars per 1,000 ton-miles and is a weighted index of the
average rates for the various runs. The method of computation of this
rate is explained in the chapter entitled "Model of Long-Term Rates."

Equations of the same form were also fitted to the specific data of the
various trades (Western vs. Eastern Hemisphere) to check for differences
between the various runs, and also between United States coastal and all
other trades in order to observe the impact of rates of U. S.-flag versus
foreign-flag vessels. No significant differences were found, with most of the
correlation coefficients being around .78, plus or minus five percentage points. The lowest correlation coefficient was .71 and applied to the following equation:

\[ y = 2.3 + 17.9/x^2 \]

where \( y \) stands for the foreign tie-ups in T-2 equivalents and \( x \) for the Persian Gulf/United Kingdom rate per 1,000 ton-miles.

Empirical relationships based on tie-ups, expressed in absolute terms of T-2 equivalents over a period of ten years, may be somewhat misleading, because the industrial capacity has increased by over 250% during this period. Furthermore, as we have argued previously, part of the idleness for repairs is, for all practical purposes, in lieu of tie-ups. For these reasons, we have calculated the tonnage idling either for repairs of over thirty days\(^1\) or for tie-ups, expressed it as a percentage of the working petroleum fleet and total tanker fleet capacity, and presented the results in Figures 25 and 26, respectively. As expected, the data show more cohesiveness, and the correlations between idle tonnage and rates are significantly strengthened. The strongest relationship between rates and idle tonnage occurs when the latter is taken as a percentage of total tankship capacity and is given by the equation:

\[ y = 3.25 + 2.515/x^2 \]

with a coefficient of correlation of .912, showing that approximately 83% of the average variation in the percentage tie-ups is explained by the short-term rate.

\(^1\)Admittedly there are some "repairs" of over thirty days which are legitimate. To the extent, however, that these approximately represent a constant percentage of capacity over time, their inclusion in the idle fleet will not falsify the results of our formulations, although it will push the lower part of the schedule to the right.
The response of owners to the movement in rates is not "lightning-prompt." We have seen in Figure 23 that the tie-ups reached their peak about nine months after the rates had reached and remained relatively close to the bottom, even though the vessels in tie-up started responding in less than two months after the rate had reached the full cost of a T-2. Our arguments do not necessarily imply that tie-ups lag behind the rate movements by nine months. What we observe may be chiefly due to the infinite elasticity of the normal and short-term supply schedules below full capacity and to the infinite inelasticity of the short-term supply schedule above the critical full capacity point. This we believe is true, but one should expect some lag behind the rates because:

1. After a swift somersault by the short-term rates, the owners would naturally undergo a period of uncertainty.

2. It takes some time, however short the duration may be, for the vessels to discharge their existing contractual obligations. For the single voyage contracts this may be approximately a month to a month and a half (if we allow also for the lead time between contract and date of delivery). The remaining life of the long-term charters will not contribute to this time lag because, as we have previously explained, the considerations leading to the tying of the chartered vessels if these are surplus are not different from those applying to vessels operating in the spot market.

3. Tie-ups are not always reported when they occur, and that is why many revisions are made later in the data. Such shifts between incidence and reporting, however, do not usually cause discrepancies of longer duration than a month.
To ascertain the existence of such short-term lags of the tie-ups behind the spot rates, we have taken a three-month running average of the idle tonnage (as a percentage of the total tanker capacity) and plotted it against rates. The results did not prove to be materially different from those presented in Figure 26.

Finally, a comment on the difference between the 1949 and 1958 data is in order. The 1949 observations appear to follow a course that indicates about 30 cents per 1,000 miles difference in the critical lay-up points, or approximately 20 U.S.M.C. points for the Maracaibo/New York run. This deviation is no doubt due to the change in the average size of the tanker fleet and the economies of scale that accrue with it.
Chapter VI

The Short-Term Supply Schedule

Having completed our general discussion of the factors that affect the supply of tankships, we are now ready to concentrate on the short-term supply schedule. This discussion will be based for the most part on material explored in previous chapters, especially in the chapter dealing with rates and idle capacity.

The short-term supply schedule, by definition, depicts the various quantities of a commodity the producers are willing to supply at different prices, under conditions of limited freedom, for adjustments in capacity. All these possibilities refer, in theory, to the same point of time, that is, they are considered as existing simultaneously. Is it possible then to determine empirically the shape of such a schedule, especially since empirical observations refer to different points of time? The answer to the question just posed is yes, though what one determines is an approximation to theoretical perfection.

We have explained that we expect the short-term supply schedule to be very inelastic beyond the full capacity level and very elastic below. Because the notion of capacity and the permissible adjustments to such capacity are vital to the definition of the particular short-term schedule (out of the many possible schedules covering short-runs of different durations) we shall now refer once again to the role of the various factors affecting capacity. After that, we shall determine the elasticity of the supply schedule.
The transportation capacity available at any moment of time can be changed by any one or a combination of the following:

1. Deliveries and/or retirements.
2. The amount of ballasted traffic (and cross-hauling).
3. The speed of existing vessels.
4. The inflow of whalers, ore-carriers, and other special purpose vessels into the oil trade.
5. The magnitude of idleness for repairs, loading, and unloading.
6. Tie-ups.

Because each of the above factors will affect supply schedules of different time duration, we must at this point decide on our definition of "short-term." At the outset it is obvious that we can ill afford to define our short run as one extending over a period of time long enough to allow for new entry or permanent exit of capacity, in response to shifts in demand that have occurred during the same time period. On the other hand, we do not wish to revert to the notion of the shortest of all possible short runs, namely, the market supply curve. The latter schedule will be mostly vertical, with deviations from the vertical occurring because of pure speculation and not because of marginal costs. In between, we can find short runs during which the capacity is fixed both in quality and quantity, with the exception of new capacity that has been initiated by conditions independent of the present demand and prices.  

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1. **Deliveries and/or retirements**

To assume independence of deliveries from current demand and prices may sound somewhat illogical, in view of our previous proof of circular dependence, yet if necessary such a concession must be made if we are to approach everyday reality. What is more, we have found that rates and orders placed are positively related, but that deliveries—as a consequence of the circularity—follow exactly the opposite path. This implies that significant shifts in the supply schedules will occur during low rates, but because the elasticity of the schedules in this price region is infinite the impact of deliveries will be harmlessly buried.\(^1\) During periods of high rates, on the other hand, when shifts would impart elasticity to an otherwise infinitely inelastic schedule, deliveries would be relatively small and rather impotent. Furthermore, there are two more avenues that we can and will follow, to eliminate the impact of deliveries.

(a) We shall assume that for each given rate there is a supply quantity equal to a fixed percentage of total capacity, regardless of any changes in the composition of the fleet. This is tantamount to assuming that the rightward shifts in total capacity are proportional to the changes in operating capacity.\(^2\) We expect to find later that the assumptions on which the above is based are not exactly correct and that changes in the composition

\(^1\) If deliveries change the size composition of the fleet extensively, then the supply schedule may shift downward and assume a more horizontal shape. For this to happen, however, the new vessels must go into the spot market. As we have seen most vessels are built after long-term charter agreements had been obtained, so they may be identified. As a result we do not expect this to be a very critical consideration.

\(^2\) Because the changes are proportional, any measure of elasticity which is based on total capacity will remain unchanged. This is in effect what Koopmans assumed in his *Tanker Freight Rates and Tankship Building*, Section 6, pp. 59-105. This measure of elasticity is not correct; it should be based on operating and not total capacity. The discrepancy at high rates, however, is small because most of the fleet is operating.
of the fleet will affect the short-term supply schedule mostly through the increase in average size and the consequent economies of scale. The manifestation of these impacts will be in the form of a wide range of values below the point of infinite inelasticity. That is, the turning points from elasticity to inelasticity will tend to gravitate downward, as will the lower limit of lay-up values.

(b) To bring our definition of short term closer to the theoretical one, we plan to eliminate deliveries from our supply schedules. This will have to be a crude approximation, because during periods of surpluses there is no way of knowing whether the new ships replace existing ones, which will consequently have to be scrapped or laid-up, or whether the new vessels themselves become idle.

For the purpose of this approximation, we shall assume that during periods of surpluses the monthly tie-ups are inflated by an amount equivalent to the new deliveries during the month, and we will reconstruct the supply schedules. No adjustment, however, will be made during periods of rising rates and tonnage shortages.

The arguments presented here concerning the new deliveries apply also in the case of retirements, but with the impact on the supply schedules reversed. As we have seen previously, however, the retirements are quantitatively insignificant and do not merit any special consideration.

So much for the deliveries and retirements. We shall now take the rest of the supply factors one by one, and see what adjustments we will have to make in order to arrive at the short-term supply schedule.

2. Ballasted traffic

The ballasted traffic does affect capacity significantly; however, geographical constraints and institutional factors limit the efficiency
that can be achieved in this area. The independents are always attempting to cut down the distance of their ballasted trips and sometimes succeed in doing so through contracts of affreightment. according to the last report of the Old Suez Canal Company, south-bound oil was only 2.8% of the north-bound, indicating that roughly 97.2% of the tanker capacity operating in the Persian Gulf/Europe trade goes back to the loading point in ballast.

Unfortunately, we cannot determine the amount of total ballasted capacity utilization. The Suez Canal data are not representative of world-wide oil movements because the trip through the Canal is one of the voyages for which we least expect oil to substitute for ballast. We suspect that the greatest efficiency in this respect is achieved by vessels operating between the Persian Gulf and the United States East Coast. Instead of returning to the Persian Gulf in ballast, these vessels may proceed to Maracaibo to accept a load for Europe, thus utilizing part of their return capacity.

We do not believe that the total carrying capacity is affected to any great extent by reductions in ballasted traffic, for the following reasons:

(a) Only the vessels operating in the spot market can contribute to such efficiency because presumably the tonnage under the control of the oil companies is always utilized in the most optimal way. Thus, only approximately 15% of the world total capacity is potentially involved.

1 Under these agreements, the shipowner undertakes to carry between two ports a specified number of tons of oil over a certain time period, but he is usually free to use any vessel he wishes and also to time the deliveries within the specified period to his best advantage.

(b) The Persian Gulf/United States run at its peak was employing only 6.2% of the total tonnage. Consequently if we assume uniformity in the charter-mix under which the fleet operates in the various runs, only 1% of the world fleet will be operating in the Persian Gulf/U.S. trade under spot charter agreements. As a result the potential impact of the ballasted capacity utilization for this run is less than 1/2% of the total fleet.

Because the amount of capacity operating in the spot market varies inversely with the spot rates, we would expect more efficiency in ballasted traffic utilization during periods of low rates. Furthermore, it is during periods of depressed market conditions that the operators are hard pressed to make ends meet. During periods of high rates, it is more profitable for vessels to hurry back to the main loading ports than to waste valuable time at the unloading area attempting to find new cargo which may be unremunerative.  

3. Operating speed

The economics of speed have been explained under our discussion of slowdowns, and pointed out that the cost of fuel enters into the determination of the level of speed in a vital way. The importance of fuel costs becomes even greater for higher than normal speeds, because the shaft-horsepower—and hence fuel—required to propel a vessel varies proportionately with the increase in speed to the fourth power and over. If the price of bunkers (fuel oil) increases with the increased activity, or through sympathetic pressure, then the use of speed-ups for the purpose of increasing capacity will undoubtedly soon be checked. Furthermore, if we exclude the tonnage

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1The buyers, knowing that the vessels will have to go in ballast to the loading ports, naturally try to strike a bargain based on out-of-pocket costs.

2Starting from 10 knots and a fuel consumption of 150 barrels per day, the speed of a T-2 can be increased by 45% to its normal 14.5 knots while the fuel consumption rises by 100% to 300 barrels per day. For a further increase of 1 1/2 knots, however, the fuel consumption increases to approximately 435 barrels per day.
that operates in the spot markets, there is no empirical evidence that the oil companies increase the speed of their fleet when rates are high. Given the *ex post facto* proof that when the rates are high the oil companies continue to draw upon the few vessels remaining in the spot market—while harboring surpluses—thus further stimulating the spot rates, we can confidently conclude that the speed of the fleet under the control of the oil companies does not change. After all why should they speed up since in the short run they have surplus capacity.

In a study of the 25,000 or so transactions completed over the last twelve years, we have been unable to discover even a single relet on high rates, although surpluses exist. This indicates beyond any doubt that the chartering activity during periods of high rates is initiated by future expectations and not by short-term needs. How else can we explain the increase in long-term contracts during such periods, (see Tables 22 and 23) the increase in lead times (between contract and delivery date), and the increase in contract durations?

Our conclusion, then, is that only the dwindling tonnage remaining in the spot market may be affected by speed-ups, but as it is such a small fraction of the total capacity, its influence, if any, will be very small, in the neighborhood of 1% at most.¹

4. **Short-run substitutes**

The total capacity of the specialized vessels (those used for whaling, carrying ore, molasses, vegetable oil, etc.) is not greater than 2% of the oil tankship capacity. Therefore, even if all these could enter freely into

¹As a result of the Suez Canal crisis, the percentage of the world fleet operating in the spot market was only 8.8% on October 1, 1957. On April 1, 1955, it was 20%. See Tables 22 and 23.
TABLE 22

Analysis of Disposition of Foreign Flag Commercial Petroleum Tanker Fleet
July 1, 1954, to October 1, 1957

<table>
<thead>
<tr>
<th></th>
<th>Owned by Oil Companies</th>
<th>Time Charters</th>
<th>Consecutive Voyage Charters</th>
<th>Single Voyage Charters</th>
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</thead>
<tbody>
<tr>
<td>7/1/54</td>
<td>46.362%</td>
<td>27.590%</td>
<td>11.002%</td>
<td>15.046%</td>
</tr>
<tr>
<td>10/1/54</td>
<td>44.762</td>
<td>28.469</td>
<td>11.150</td>
<td>15.619</td>
</tr>
<tr>
<td>1/1/55</td>
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<td>27.427</td>
<td>9.124</td>
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<td>4/1/55</td>
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<td>26.645</td>
<td>9.163</td>
<td>20.037</td>
</tr>
<tr>
<td>7/1/55</td>
<td>44.254</td>
<td>27.364</td>
<td>8.968</td>
<td>19.414</td>
</tr>
<tr>
<td>10/1/55</td>
<td>44.542</td>
<td>29.126</td>
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<td>1/1/56</td>
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<td>10.632</td>
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<td>4/1/56</td>
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<td>42.268</td>
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<tr>
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<td>41.595</td>
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<td>8.760</td>
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<tr>
<td>10/1/57</td>
<td>41.234</td>
<td>33.320</td>
<td>16.944</td>
<td>8.502</td>
</tr>
</tbody>
</table>

Source of Data: Marine Transportation Department, Socony Mobil Oil Company, Inc.
TABLE 23

<table>
<thead>
<tr>
<th>Date</th>
<th>Percentage of World Tanker Fleet Trading on a &quot;Spot&quot; Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/1/54</td>
<td>15.0%</td>
</tr>
<tr>
<td>10/1/54</td>
<td>15.6%</td>
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<td>1/1/55</td>
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<tr>
<td>4/1/57</td>
<td>11.0%</td>
</tr>
<tr>
<td>7/1/57</td>
<td>8.8%</td>
</tr>
</tbody>
</table>

Source of Data: Marine Transportation Department, Socony Mobil Oil Company, Inc.
the oil trade, their impact would be limited. In addition to the long-term contractual commitments that will undoubtedly inhibit the movement of the specialized fleet, there is the problem of the cost of conversion. It is doubtful that a capacity equal to even 1% of the total oil fleet capacity can be contributed by outside sources.

5. Idleness due to repairs, loading and unloading

Repairs may be cut, and there are evidences that this has happened when rates were high. Here again, however, the capacity involved, if we include improvements in technology, is not greater than 1%-1 1/2%. As for idle port time, it is quite expensive under any circumstances, and conscious efforts are made to eliminate it, regardless of rates. Beyond a certain point, however, the costs associated with preparedness of the shore installations become so prohibitive that it is unwise for anyone to attempt it.

So far, we have considered all the factors that contribute to the increase in capacity, and found that if we exclude deliveries, which are from the theoretical point of view an intermediate or long-run impact, the rest do not constitute any important source of short-term expansion. Utilization of ballasted traffic is more likely to appear under depressed or normal market conditions, and even in such cases its impact is not significant. Speed-ups are very expensive and, because of the consequences of elastic expectations, are not practiced. Conversions of other vessels into oil tankers cause shifts in the short-term schedules, for which we must make adjustments. Luckily, however, the capacity flowing into the tankship market from this source is not expected to be even 1/2% of the total tanker capacity. Finally,
we have said that repairs may be cut, and we expect that this cut will increase total capacity by approximately 1%-1 1/2% of total capacity. Such an impact will shift the vertical portion of the supply schedule rightward.

Our general conclusion on the basis of the evidence uncovered is that the short-term schedule for tankship services is extremely inelastic, beyond the theoretical full capacity point. (We shall postpone defining this "theoretical full capacity" until after we have finished our discussion on the factors that operate on the short-term supply schedule below full capacity.)

6. Tie-ups

When rates are low and surpluses begin to appear, the unemployed vessels are forced out of the market. We have previously explained how the various stages of idleness succeed each other, and will not repeat the discussion here. Because of such withdrawals from the active market, the supply schedule assumes a slope; but on the basis of purely theoretical considerations the value of such a slope, below the turning point, is expected to be close to zero.

The elasticity of the lower part of the supply schedule is due mainly to the existence of a rather homogeneous marginal capacity of considerable magnitude. As of January 1, 1959, approximately 13% of the total carrying capacity was contributed by T-2s constructed during World War II. In addition, another 5.8% of the total capacity consisted of pre-war vessels of 10,000 DWT. and over, but these vessels were used mainly for special trades, such as cargo and products for markets that were not amenable to mass distribution. Consequently, the pre-war tonnage, with the exception of periods of abnormally high rates, will be able to compete only in specialized
segments of the total market. It is expected, however, that these vessels will enter into other areas of the market in periods of excess demand. Thus, at best, this tonnage will help define the region of unit elasticity of the supply schedule.

Once this special tonnage withdraws from the market, the rates are expected to reach very quickly the lower limit of the T-2 lay-up point, which we have previously defined and calculated as being between 62 and 68 cents per 1,000 ton-miles (depending on the route). When the rates go below, let us say, 70 cents per 1,000 ton-miles, massive withdrawal of these T-2s occurs, which renders the short-term supply schedule very elastic. If, on the other hand, the rates go slightly above 70 cents per 1,000 ton-miles, many of these vessels will be reactivated and thus arrest the recovery of rates. This process will be continued until demand, or expectations about future demand, absorb all the tonnage in tie-up.

One may ask what guarantees that a homogeneous marginal capacity of sufficient magnitude will be always available. Perpetual availability of such blocks of tonnage is clearly necessary to impart generality to our previous conclusions. Luckily there is such a guarantee in the cyclical movements of tankship building and the advance in technology, which together generate new favorite sizes with each new shipbuilding boom.

There are certainly other factors which contribute to the elasticity of the lower part of the short-term supply schedule, the most prominent being the marginal operating costs of vessels and the average tie-up costs. Because of the "time fixity" of most of the operating costs and the "size fixity" of most of the tie-up costs, the lay-up rate of vessels narrows, and the marginal capacity is increased by the tonnage of neighboring sizes.
Definition of Capacity

If we define the theoretical full capacity in terms of ton-miles of cargo carried and use an approximate 3% of the world total one-way carrying capacity for ballasted capacity utilization, we will find that the feasible (economic) carrying capacity of the fleet on the basis of the 1958 data does not exceed 40.2% of the total. In other words, if we define as total capacity the aggregate ton-miles that a vessel can carry when steaming 365 days per year, we will find that only 40.2% of this absolute is used. Repairs are expected to take away approximately 7% of the total, and port calls 15%,\(^1\) thus leaving only 78%. Ballasted traffic will further reduce this by 37.8%, leaving 40.2% as the maximum usable capacity.

Because the average distance over which oil is carried does not remain constant, the usefulness of ton-miles of oil carried is somewhat limited as a measure of capacity. Taking, for example, the capacity of a T-2 operating between Maracaibo and New York versus the same vessel operating between the Persian Gulf and Antwerp, we find that the capacity differential is approximately 11%,\(^2\) and in favor of the longer run. For a short-term schedule as sensitive as that of tankships, at or near full capacity, such a difference is statistically very significant. Furthermore, the entry and exit of vessels will cause shifts to a short-term schedule based on such a measure.

\(^1\)This percentage is based on the 1958 employment figures of the fleet and is likely to change with the geographical distribution of oil sources and markets. The longer the oil has to travel, the lower this lost capacity will be.

\(^2\)The T-2 capacity for the Maracaibo/New York run is roughly 700 million ton-miles, and for the Persian Gulf/Antwerp trade 775 million ton-miles. The difference is due to the number of days spent in port.
Instead of ton-miles we have decided to use the notion of "operating fleet as a percentage of the total fleet," and for the measurement of the elasticity of supply we will use an index based on the "working petroleum fleet" rather than the total fleet, because such an index depicts changes in the level of employment more accurately.

The "operating fleet" is defined as the total fleet less the tie-ups and vessels idle for over thirty days. The reason we exclude vessels idle longer than thirty days is that we believe some idleness is in lieu of tie-ups. Ideally we should have excluded also some repairs of less than thirty days, because if repairs of over thirty days are inflated, surely those of less than thirty days must be also. However, with the exception of 1958, we do not have any data for such repairs, consequently we will assume that all repairs of less than thirty days are essential.

Inherent in our definitions of capacity and the exclusion of extended repairs is the premise that normal idleness due to essential repairs lasting over thirty days is a constant percentage of capacity. This may not be exactly true in the long run, because of changes in the size and age composition of the fleet, but we feel, nonetheless, that even in the long run such an assumption is much less harmful than the acceptance of all stated repairs as necessary repairs. In the short run, which is the focus of our attention, the impact of such changes in the age and size composition of the fleet on the extended repairs will not cause perceptible changes. Any short-run impact on repairs of less than thirty days is reflected in the available capacity, by our inclusion of such repairs as part of the "operating fleet."
Exclusion of repairs of less than thirty days from the available capacity would imply that either these repairs are not a necessary part of readiness, an assumption which is not correct, or they are a constant percentage of available capacity in which case it will be of little consequence whether these repairs are included or excluded. So our decision was to include them in available capacity as an essential part of the operating fleet, realizing that such inclusion may introduce some error (which we cannot separate) caused by repairs of less than thirty days in lieu of tie-up. In trying to assess the quantitative significance of such an error we must realize that the probability for such occurrence is very small, especially in periods of high rates. Furthermore the amount of repairs of less than thirty days at any moment of time, may not exceed 4% of the total capacity as can be seen in the 1958 data of Table 17. To summarize then, although our calculations include some elements of error their quantitative impact is insignificant even for a schedule as sensitive at high rates as the short-run supply schedule.

The "Working Petroleum Fleet" differs from the "Operating Fleet" in that it excludes, in addition to tie-ups and repairs of over thirty days, government owned vessels operating in the oil trade and special purpose vessels.¹

The main disadvantage of our definitions of capacity is that these do not record the impact of speed-ups or the efficiency of utilization of the ballasted traffic. However, the contribution of these two factors to capacity is negligible, especially within the regions of sensitivity of the supply schedule.

¹Those carrying molasses, vegetable oils, ores, and chemicals; and depot ships, lake tankers, etc.
The Supply Schedule

Figure 27 presents the scatter diagram of the monthly "operating fleet as a percentage of the total fleet" versus spot rate per 1,000 ton-miles. The striking feature of the exhibit is the inelasticity of the schedule for operating fleet values of 95% and beyond. The critical rate seems to be around 90 cents per 1,000 ton-miles, which, as we have seen (cf. Table 21), represents the out-of-pocket costs for a T-2. It is also very interesting that, below 70 cents per 1,000 ton-miles, the short-term schedule becomes infinitely elastic and the rate seems to be settling around 61 cents, which is very close to what we found as the refusal rate for a T-2.

The upper part of the schedule possibly shows evidence of bending backward, but not in any pronounced fashion. If the schedule does actually bend backward, it may be exhibiting the impact of elastic expectations and speculation based on them.

By definition, the difference between 100% and each observation at the various rates represents the capacity idle because of tie-ups or for repairs of over thirty days. Any change, therefore, in the average duration of repairs of over thirty days will cause shifts in the schedule. Evidently such a shift took place during 1957, and the schedule shows that the average duration of repairs must have decreased by approximately 5 1/2 days during the year.

Another point that merits mention is the width of the elastic part of the schedule. It indicates that the average lay-up rate of the marginal

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1 In effect, the equation for the supply schedule is based on that of Figure 26: Operating Fleet = 96.75 - 2.515/x
vessels has decreased over the 10-year period by no less than 30 cents per 1,000 ton-miles. Of course, not all the range (width) in values can be attributed to lower marginal costs. Some variation undoubtedly is due to expectations, as the 1949 data clearly show. Possibly this is an instance in which elastic short-term expectations caused early withdrawals, during both the downswing and the recovery of rates.

In order to obtain statistical measures of the elasticity of supply, we need data on the percentage changes in the employed capacity. The definition of working petroleum fleet is such that it gives us the best approximation of what we want. It excludes commercial vessels belonging to governments, which are not amenable to the calculus of marginal costs, as well as vessels operating in special trades that for all practical purposes constitute separate markets. Therefore, changes in the idle capacity, expressed as a percentage of the working petroleum fleet, will give us the best approximation to the numerator of the elasticity formula.

The short-term supply schedule, based on the working petroleum fleet, is shown in Figure 28. The general characteristics of this schedule are not different from those observed in Figure 27. Up to 92% of "capacity" the elasticity is infinite, but the schedule suddenly becomes unit-elastic around 93%. Between 93.0% and 94.1% and 95.6%, and it remains at approximately 0.02 between 94.1% and 95.6%, and it remains at approximately 0.02 up to 97.2%. From then on--beyond $2.50 per 1,000 ton-miles--the elasticity is zero.  

These results show that the "frictional unemployment" and any necessary repairs extending over thirty days do not exceed 3% of the total working petroleum fleet.

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1 These results show that the "frictional unemployment" and any necessary repairs extending over thirty days do not exceed 3% of the total working petroleum fleet.
To avoid shifts in the supply schedules, which plague statistical analysis, one should collect data during periods of rather rapid price changes, preferably during downward movements. The latter will guarantee that there will be little interference from shifts in the observations caused by movements from the short-term to the intermediate schedules. We have such a period of ideally fast price changes starting with January, 1957.

The 1957 and 1958 data, adjusted for deliveries and plotted against rates, are presented in Figure 29. In adjusting for deliveries, we assume that the new deliveries take employment away from the existing fleet, and therefore we subtract from the idle fleet an amount of tonnage equivalent to the capacity delivered. The results of this exhibit have really exceeded our best expectations; there is a perfect correspondence between the empirical schedule and what we expected to find on the basis of purely theoretical deductions. The encircled observations represent the result of temporary rate changes, during the months of August, September and October of 1958 (see Figure 23) with consequent reactivation of tonnage. Because the expectations about demand were not sustained, the rates returned to their prior level but left more fleet actively seeking employment than before.¹ This occurred during the fall months, when as a result of winter inventory built-up seasonal shortages are usually observed, and so it set the stage for another performance similar to the one that took place about twelve months before. These surplus vessels remain in the market for a while seeking

¹This is one of the causes of the flatness of the short-run supply schedule below the point of full capacity.
employment until disillusionment leads them back to tie-up a few months later. We read in the July 1, 1959 *Tanker Market Report* of Davies & Newman, Ltd., London:

"Events in the tanker market during the past month followed very closely the pattern set during the preceding two or three months. The laid-up fleet has continued to increase, and now stands at around 440 vessels totalling 7,395,000 tons deadweight, a further increase during the month of 20 vessels of about 395,000 tons deadweight."
Chapter VII

Characteristics of the Tankship Markets

In view of what we have previously said regarding the organization structure of the oil industry, one would expect the tankship markets to be oligopolistic in terms of both ownership and effective behavior. If the producers and distributors of crude oil are vitally affected by fluctuations in tank-ship rates, because these fluctuations are reflected in the posted as well as delivered prices for oil, then the only solution is to stabilize the cost of transportation. Otherwise any change in the cost of transportation will upset the very delicate balance that exists between the prices of the oil originating from the various geographical regions and destined for the major consuming markets. So one would expect on first glance the ownership of tankers to be heavily if not totally concentrated in the hands of the major oil producers. This, however, is not the case, which implies that any price stability that may exist in the oil markets is not achieved through ownership or control of transportation facilities.\(^1\) As of January 1, 1959, there were over 600 tanker owners with none owning more than 7% of the total capacity available, so complete control by a few is out of the question.

If we glance at Table 24, we notice that there is much more concentration of ownership among the oil companies than there is among the independents. The five major oil producers (or associated companies) own approximately 68% of all capacity owned and constructed by oil companies. This, of course,

\(^1\)This does not imply that the cost of transportation is left to become an exogenous factor. The impact of transportation may still be eliminated by arrangements that favor a delivered price with all the profit imputed to production.
TABLE 24

Tankers Owned and Under Construction for Five
Major Oil Companies and Five Major Independents

January 1, 1959

<table>
<thead>
<tr>
<th>1. Oil Companies</th>
<th>Ownership</th>
<th>Construction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Oil Co. (N.S.)*</td>
<td>201</td>
<td>166</td>
<td>367</td>
</tr>
<tr>
<td>Shell</td>
<td>207</td>
<td>101</td>
<td>308</td>
</tr>
<tr>
<td>British Petroleum</td>
<td>151</td>
<td>141</td>
<td>292</td>
</tr>
<tr>
<td>Gulf</td>
<td>78</td>
<td>61</td>
<td>139</td>
</tr>
<tr>
<td>Caltex</td>
<td>65</td>
<td>37</td>
<td>102</td>
</tr>
<tr>
<td><strong>Total Above</strong></td>
<td>702 (67.5%)</td>
<td>506 (68%)</td>
<td>1208 (68%)</td>
</tr>
<tr>
<td><strong>Total All Oil Cos.</strong></td>
<td>1038 (100%)</td>
<td>742 (100%)</td>
<td>1780 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Independents</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Niarchos</td>
<td>118</td>
<td>27</td>
<td>145</td>
</tr>
<tr>
<td>Onassis</td>
<td>65</td>
<td>54</td>
<td>119</td>
</tr>
<tr>
<td>National Bulk Carriers</td>
<td>88</td>
<td>21</td>
<td>109</td>
</tr>
<tr>
<td>Goulandris</td>
<td>75</td>
<td>26</td>
<td>101</td>
</tr>
<tr>
<td>Livanos</td>
<td>44</td>
<td>11</td>
<td>55</td>
</tr>
<tr>
<td><strong>Total Above</strong></td>
<td>390 (19%)</td>
<td>139 (12%)</td>
<td>529 (16.4%)</td>
</tr>
<tr>
<td><strong>Total All Independents</strong></td>
<td>2066 (100%)</td>
<td>1162 (100%)</td>
<td>3228 (100%)</td>
</tr>
<tr>
<td><strong>Total of Above 10 majors</strong></td>
<td>1092 (35%)</td>
<td>645 (34%)</td>
<td>1737 (34.7%)</td>
</tr>
<tr>
<td><strong>World Total</strong></td>
<td>3104 (100%)</td>
<td>1904 (100%)</td>
<td>5008 (100%)</td>
</tr>
</tbody>
</table>

*Includes Standard-Vacuum: 22 T-2s owned and 8 T-2s under construction

Source of Data: Tables 1 and 3
should be expected given the influence these companies exercise on oil trade. We must add, however, that the ownership of all the oil companies combined is not greater than 34% of the world total, consequently the ownership of the five largest oil companies is only 23-24% of the world total. The five major independents, on the other hand, do not control more than 19% of the independent capacity, or 13% of the world total. Their share of the construction in progress is even less, being 12% of the total construction initiated by independents and about 7% of the total world-wide tanker construction.

Looking at the combined ownership of the five major oil companies and the five major independents, we find that 1 1/2% of owners control 35% of the total world tonnage. On the basis of purely quantitative information, as a result, one would say that although no one owns more than 7% of the total, to the extent that the remaining 65% of capacity is so thinly dispersed among 98 1/2% of the owners a few of the majors could control the market if they behaved accordingly. Such control will be much easier, as well as vital, to establish in a market such as that of tankships which is influenced by price-elastic expectations, and which is so sensitive to small variations in capacity when it reaches 95% of total utilization. Do the tankship markets then operate under the impact of oligopolistic influence? The answer is no! Although logic as well as ownership composition could imply the contrary, the tankship markets operate more like perfectly competitive markets. Let us now analyze the reasons behind this paradox:
1. Concentration of Ownership in the Relevant Market

Although both oil companies and independents own vessels, for purposes of rate determination the relevant market is the spot market and the latter is usually composed of the independent fleet only. The vessels of oil companies rarely enter into the spot market, and when they do enter it is only during periods of depressed rates.

The concentration among the independents is not very great. In spite of this, because of the inelasticity of the supply schedule at 94% of capacity utilization and beyond, and the infinite elasticity below 92% any one who has at his disposal 3-4% of capacity can very effectively exercise price leadership and organize the market. This however does not happen because no one has all his vessels in the market at any moment of time. In order to reduce the risk of unemployment, multi-unit owners space the availability of their vessels by accepting time charters for 75% to 90% of the capacity they own. As a result, the concentration of ownership of vessels operating in the spot market at any moment of time is very small indeed, with no one owning more than 1% of the available capacity.

So the spot market is the relevant market, and it is in this that we look for clues of tankship market behavior.

2. Balance Between Production and Refining Capacities

Our discussion on the impact of concentration on the structure of the tankship markets, drew upon empirical observations to show "what is," that is to say that there is no significant or effective concentration of ownership in the tankship markets, especially in terms of what is available in the spot market at any moment of time. One may ask, however, why should it be so? For is not there enough motivation for the oil companies to either organize the markets or eliminate them completely?

There are several reasons for the relatively low degree of concentration which also explain, why the oil companies are not and cannot feasibly be self-sufficient in transportation. One of these reasons is the imbalance between the production and
refining capacities of each of several oil companies. Once such imbalance is admitted then the oil companies cannot preserve their autarchy in planning or their independence of action even if an initial understanding about posted prices is reached. Oil companies must as a result decide on sale prices, and transportation costs become then critical. Self-sufficiency in transportation by all will obviously create surpluses and costly waste. It is also obvious that complete dependence of some oil companies on others for transportation capacity (reflected in terms of delivered oil) will not be satisfactory. No one will accept the arbitrary decision of someone else as to what constitutes a fair transportation charge.

The facts which motivate behavior in this case are clear, as far as the oil companies are concerned: (a) fluctuations in transportation costs are considered undesirable and must be somehow eliminated from being a consideration in pricing decisions and (b) a realization that no one can impose his will upon the rest, because no one can afford to be completely self-sufficient. As a result, those who are endowed with excess production capacity have to choose between two feasible alternatives. They can either (i) sell on both F.O.B. and C.I.F. basis but establish the C.I.F. price in a way that will make the buyer indifferent between F.O.B. and delivered basis, or (ii) sell on F.O.B. basis only and have the buyers provide means of transportation either owned or chartered.

It is obvious that the oil companies cannot strictly adhere to an F.O.B. price. Fluctuations in transportation costs will be reflected in the cost to the buyer and will affect his purchasing plans. Whenever rates are low, given a certain pattern of F.O.B. prices, the oil which travels the longest will be relatively favored, and when rates are high the one closest to the buyer will be in the most advantageous position. Such possible changes in sources of supply will undoubtedly introduce a lot of uncertainty in the sales budgets and production plans of oil companies and also possibly leave the oil companies to the mercy of those who may happen to control transportation. So an F.O.B. price is not practical.
Selling on a delivered basis, therefore, is the only solution to the dilemma facing the oil companies. The difference between the F.O.B. and delivered price, however, must not be higher, under normal conditions, than the market cost of transportation (or what it would have cost the buyer if he had his own vessels.) In fact in order to eliminate some instability from their sales and investment plans, the producers may offer an incentive in terms of lower transportation costs, and so encourage them to choose a delivered price.

We must notice that under both alternatives (i) and (ii), the market price for transportation services will be established under competitive conditions. In the first case, an integrated oil firm will not allow anyone to interpose a transportation price, between production and refining and between refining and the consumer, which includes monopolistic rent. In order to guard against such an eventuality, the oil companies will be forced to obtain their own transportation capacity, at least for part of their total needs. In the C.I.F. case, the transportation cost that is included in the delivered price, must be based on long-run costs of tankship services and must include the minimum return that is necessary to keep the required investment in the industry. It cannot be higher than long-run cost because otherwise the buyers will prefer to buy on an F.O.B. basis and own their own vessels (or charter from independents.) Once such a long-run cost is established and included in delivered prices, the owners of vessels operating in the market cannot price their services on a different basis. So under either alternative the tankship markets will operate in a manner approaching perfect competition.

3. Balance Between Needs and Sources Satisfying Such Needs for Each Company by Geographical Regions

Given that geological accidents determine the location as well as the quantity of oil produced, the probability is quite large that there will be imbalances between the geographical and the resources available to the various oil companies in those
regions. Such an occurrence will encourage the producers to exchange (barter) their oil in order to eliminate excessive wasteful cross-hauling. As a result the barterers will find it necessary to establish transportation rates that are objective and acceptable to all the parties involved. To be sure no rate will be universally acceptable unless it is established in a "competitive" market, or else it is based on long-run cost. For the latter, to be broadly acceptable it must be the result of known technology of operation and of production functions that can be reproduced. Again here these conditions are characteristic of perfectly competitive markets.

4. The Existence of Tankship Markets

The arguments that we have thus far presented point out the necessity for company owned vessels and an independent tanker market. The oil companies cannot afford to operate under an unstable oligopolistic situation nor would they be willing to become completely dependent on someone else by relinquishing control of transportation facilities to a monopolist. Consequently, they must own vessels for at least part of their transportation needs if they are to preserve their independence of action. On the other hand they cannot afford to be completely self-sufficient because they will be then creating surpluses and wasteful cross-hauling. For these reasons there must be a tankship market.

The tankship markets are the consequence and not the reason for the perfectly competitive conditions under which tanker rates are established. These markets operate in a manner similar to the stock market. The owners of vessels normally report the availability of their tankers to brokers, who, through their offices at the various parts of the world, attempt to place these vessels with customers who have transportation needs. On the demand side of the market, the oil companies and other people who need vessels register their needs with brokers, who try to match supply and demand in total and also bring about an equilibrium in the markets by geographic areas.
There are cases of transactions that occur outside the organized markets, for which the parties get together on a private basis, without intermediaries. More often than not, these transactions are for time charters of extensive duration. This practice of bypassing the brokers, however, does not diminish the importance of the organized market nor does it affect its perfectly competitive nature. The spot rate as established in the tankship markets serves as a basis for the private agreements, but the brokerage fee is avoided as in the case of private real estate sales.

5. **Mobility**

The existence of a tankship market and tanker brokers does not by itself guarantee that the markets will behave in a perfectly competitive manner. For example, no one can claim that the real estate markets are *ipso facto* perfect. In the case of tankers, however, we have a unique feature in the form of mobility, which encourages competition even further.

Mobility is very vital not only because it reduces the cost of exit from a particular market, but also because it serves toward global equalization of supply and demand. The total amount of capital invested in tankships, as well as in any other type of a vessel, is mobile and as a result the productive capacity is not fixed in any geographical area. Although this mobility does not result in a costless entry and exit from the industry, yet no doubt it does allow some flexibility even on that score. For if the total investment is mobile as a going concern, naturally the resale price will be higher than it would have been had the concern been dismantled and sold in pieces.

Normally in other forms of investments in capital equipment once the capital has been committed it is for the greatest part completely sunk in the geographic area. An individual can get out of the venture either through sale on a going concern basis, and of course at a price reflecting the estimate of the buyer as to the risk and profitability involved in that particular industry and geographic area, or by means of physical transfer of all
moveable assets which again cannot be achieved without a consider-
able loss. The respective economic forces in the tankship markets are different however. Capital is mobile in that the owner of a tankship can move his whole firm from port to port and hence enter into different geographic markets with very little cost. This characteristic makes for a more competitive international market because it tends to equalize rates by balancing supply and demand.

A question now arises as to whether this observation is pointing out at one of the difficulties the oil companies face or will face in any attempt to control tankship tonnage capacity for oil price regulation. In the early history of the oil industry in the United States, before the industry became international and the tanker an important mode of transportation, control of railroads meant control of the markets. Why then do we not find a comparable situation today? Is it by accident or by design that the oil companies own only a small share of the total transportation capacity? The answer of course is that it is by no means an accident. Economic and institutional considerations make it impossible for anyone to control the market. Some of these factors we have already pointed out and more we will discuss shortly, but mobility is one of the most important determinants of the character of the tankship markets. In the case of railroads the greatest part of the capital investment is fixed not only in terms of time extending over several tanker life cycles but also in a physical sense. For these reasons the cost of entry and exit from the industry and specific geographic markets is much heavier in the case of the railroads than in the case of tankers. That is why it is difficult for absolute control and monopolistic conditions to flourish in the tankship markets.
6. Ease of Entry

We have argued under "mobility" that it is easy to move tankers from market to market and so at the same time facilitate exit from the industry itself. Now we will examine the question of entry to the industry.

One thing that strikes the empirical analyst of tankship operations, is the relative absence of obvious overall administrative and financial economies of scale. As a result a tanker owner needs no administrative superstructure in order to operate efficiently. When the vessels are away from their home base the owners can very efficiently relinquish day to day operational control to the captain of the vessel, use the offices of tanker brokers at the various ports for employment if necessary and use local suppliers for essential stores.

The presence of brokers may not necessarily imply the absence of economies of scale of overall administrative or financial nature, especially if we include in these managerial activities a risk optimum. It may rather indicate that the scale necessary for achieving some or all of these optima for the firm is so large that it will be uneconomical for anyone to achieve it given the present market needs. Either hypothesis, however, points out that the feasibly optimum scale for the firm is so small to make it very easy for anyone to enter the market.

Since the overall optima for the firm are not instrumental in inhibiting entry into the industry, we will now examine whether the size of the operational units presents any problems. Taking the largest vessel afloat in 1959 we find that it is not greater than .002% of total capacity. Consequently, and even if the largest vessel available represents the most efficient size for all purposes, there will be a need for over 500 such vessels to satisfy the total transportation requirements of the industry. As everyone knows, however, there are all sorts of limitations restricting the use of these large vessels, such as loading and unloading facilities,
refinery capacities, and market needs, so the average optimum size given these limitations may not be greater than .0004% of total capacity, thus pointing out that approximately 2,500 vessels may be required to satisfy industrial needs. Under such conditions entry into the industry is quite easy.

The financial risks that the owners undertake when they invest in tankers need not be great either. We have already noticed that at the time when most ships are ordered, the owners do not have to finance the building of the vessels themselves. Usually the banks, insurance companies, and trust funds provide up to 80 and sometimes even 90 per cent of the needed capital on the basis of a bonafide charter agreement. We have also shown that during periods of strong demand and shipbuilding boom the length of the time charter tends to increase, consequently, it is not unreasonable for a bank to expect to collect the total amount of the loan in five years out of the net charter rental. Such an arrangement removes most of the financial risk from the plans of the owner and leaves enough capacity beyond the expiration of the original charter so that the owner can realize a healthy profit over the remainder of the life of the vessel. It is also for this reason that such a vessel following the original charter agreement may continue operating in the spot market at rates below long-run average cost and still prove to be a wise investment decision. The financial institutions do not necessarily take undue risks in this case, because first of all as we have said, they arrange so that the proceeds from the charter are applied directly toward the payment of the loan installments and also require an insurance policy to cover their investment in case of a natural disaster. All in all then, the only prerequisite for obtaining the money for building a vessel are the building plans and a charter signed by an oil company.
In summary then, entry into the industry is relatively easy, because: (a) overall administrative and financial optima are not operationally present, (b) the optimum size of the average operational unit is very small, so given the transportation needs of the industry there is room for over 2,000 such units, and (c) capital for investment in tankers is rather plentiful and relatively riskless.

7. The Vessel is the Firm

One important conclusion that emerges very clearly from our discussion under "mobility" and "ease of entry" is that for all practical purposes, the vessel is the firm. Administratively, it is under the jurisdiction of its captain for most of the time. Only loose supervision can be exercised by the home office, because given the distance that separates the point of action from the point with which overall administrative control rests, effective central control cannot be exercised. The farther the distance, other things equal, the looser the control. Furthermore, the nature of the decisions that are characteristic of tankship operation necessitates flexibility for quick action. The expected loss due to idleness and indecision at a far away port, until the feedback control mechanism operates to transmit new directives, is far greater than the expected loss because of suboptimal decisions on location by the captain.

In addition to what was stated above, one must not forget the traditional role of the captain of a ship. He is the master of his vessel with the power to perform many more functions than those falling under any notion of liberal administrative theory. He crosses international boundaries, operates under international laws and whenever necessary, he is the law. All these arguments show why administratively the vessel is the firm.

Now what are the economic reasons for and the consequences of such administrative entity? The fact that the optimum size of the vessel is very small relative to the total capacity for the
industry we have already mentioned. This economic rationale, however, carries with it certain implications that are embodied in the existence of a neat and separable unit of capacity, the vessel. The first implication is that economic planning may be carried out on a vessel to vessel basis independent of anything else. Each vessel can pursue its own independent employment. Because of the absence of any administrative superstructure and with no knowledge or preoccupation about fixed costs, decisions are likely to be made on an out of pocket and opportunity cost basis. As a result the price mechanism operates as in the case of perfect competition where the price is equal to the marginal cost of the marginal vessel in operation.

A second consequence of the notion that every vessel is a firm is the relative absence of complementarities of resources. Because complementarities of resources are rather absent the vessel can fit into the organizational structure of any firm and perform as effectively as if it were still in the parent organization. Consequently, whenever excess capacity exists and because the cost of such excess capacity, in terms of our of pocket expenditures, is very high, there is a tendency for the oil companies to throw into the market their surpluses and relet to other oil companies or to the independents. Arrangements such as these are unique and are not found in many other types of productive facilities such as, for example, in manufacturing.

Finally there is a further consequence of the absence of complementarities in the fact that technology of operation is common to all. Complete knowledge of technology is characteristic of perfectly competitive operations. Of course some may say that it is not clear which is the cause and which is the effect. Frankly, it makes no difference because the end result is the same. Although we feel that the technology of tankship operations is very simple and well known on a prior basis, it were not otherwise common, with the practice of the oil companies to relet their excess capacity, technology can become common very rapidly.
There is ample empirical evidence that the vessel is treated as the firm. (a) Charters very rarely fail to mention specific vessels. (b) The independents in their discussions treat the vessels as continuous projects. (c) Vessels are being built irrespective of overall market considerations and (d) Contracts for new buildings are initiated and financed by charter agreements.

All of the above arguments point to one thing, the perfectly competitive nature of tanker markets.

8. Absence of Artificial Controls

Related to our arguments on mobility is the issue of artificial controls. The operation of tankships is one of the least controlled because it is international. With the exception of the United States Coastal Trade that is by law limited to tankships flying the flag of the United States and a few partial protectionistic attempts by France, Italy, and Japan, the routes are not pre-empted to the ships of any particular country. In this way economic rather than any other type of considerations are paramount. We must also notice that there are no franchises on routes, as one finds in other modes of transportation, thus further contributing to the competitive nature of the markets.

We have thus far shown that the tankship markets although on the basis of common sense and on a priori characteristics should be imperfect, they operate like perfectly competitive markets. Having resolved this paradox we will now summarize several other characteristics of tankship operations.

Because the spot market is always very thin, consisting of 10 to 15% of total capacity, it is very excitable. Given this and elastic expectations, we may find in many cases that the oil companies follow a leader in the wrong direction, and further accentuate the fluctuations in the market. Such leadership, however, does not bring about stability as the "price leadership" of oligopolistic markets, but rather accentuates the chaotic
conditions of a perfectly competitive market in which the operatives make
decisions on erroneous information. For example, when tonnage demand is
low, many oil companies withdraw from the tanker market because they own
enough tonnage and have enough charter commitments to last them in the
foreseeable future. In addition, their stocks of oil may be such that they
can afford to postpone transportation for quite a few months to come. Their
withdrawal from the market, however, may be interpreted as a loss of confi-
dence in the tanker market and an expectation for further weakening which
in turn may induce the smaller charterers to withdraw. This indeed results
in further weakening which justifies the otherwise unjustifiable expectations
which induced it. In other words, while the expectations of the major oil
companies are biased and unjustifiable yet, by their behavior they can
influence the behavior of other operators who in turn may react by with-
drawing from the market. Their withdrawal can cause a precipitation
in the rates and thus ex post facto bring about a justification of the
original biased expectations. The opposite, of course, can occur in
periods of excess demand. So leadership in the tankship markets widens
the fluctuations and causes further instability.

Another characteristic of the tankship market is that the fortunes of
all are tied together. Because of the oligopolistic nature of the end
product markets and the overlapping territories in which the oil products
sell, an increase or decrease in total demand will affect all the producers
in more or less the same qualitative way. In other industries, one
geographic region may be depressed while others prosper and thus changes
may affect the various firms differently depending on the geographic area
that they serve. In the oil industry, however, one is dealing with a
universal market for a more or less homogeneous and highly substitutable
product, so any change will affect all of them in the same direction. Hence the demand for tonnage either skyrockets or goes to the bottom for all at the same time.

What we have just said refers to the direction of the impact and not the quantitative magnitude of changes in the individual transportation needs. To the extent that all oil companies share the same total demand, given any particular demand level, we expect that most of the covariances between the transportation needs of oil companies to be negative. It is for this reason that the operations of the tankship markets serve toward more efficient utilization of tonnage by mitigating the risk and reconciling surpluses and deficits.
Chapter VIII

The Formation of Short-Term Rates

All the necessary analysis leading to the formation of short-term tanker rates has been presented in the previous chapters; here we will recapitulate our findings and bring a few points into clearer focus.

At the outset we have shown that the elasticity of demand for oil is very small. The elasticity becomes smaller, the shorter the duration of time covered, but even for a schedule of a year's duration the elasticity index of the demand for oil is not far from zero.

Then we turned our attention to the supply schedule and have proved that short of a shipbuilding cycle, the supply schedule is very inelastic beyond full capacity. The lower part of the supply schedule, in contrast, is very elastic because of the refusal rate of the marginal vessels. The latter constitute a substantial part of total capacity; hence, within the relevant range of fluctuations in capacity, the lower part of the supply schedule is completely horizontal. The change from elasticity to inelasticity occurs within less than two percentage points of total capacity and indicates that a shift in the demand by as little as 1% around the critical area will be enough to create fortunes or disaster. With an elasticity of supply of .02 immediately beyond full capacity, a shift in oil demand of 1%, and a consequent shift in transportation demand of 1.66%, \(^1\) will increase rates by no less than 83%.

\(^1\)From the data presented by Kahle and Kelly at the Fifth World Petroleum Congress on May 30, 1959, on The Role of Sea Transportation in the Petroleum Industry, one can see that for the period of 1950-1958, requirements have increased by an average factor of 1.66 for every percentage increase in oil demand transportation. The factor of 1.66 refers to a relative and not absolute change. In absolute terms we find that the transportation requirements increase by an average of .536 T-2s for each million U.S. barrels of increase in petroleum production. The marginal rate has been steadily increasing and over the time span covered by this study appears to be 64 T-2s, indicating that petroleum is transported over longer and longer distances.
The behavior of the buyers and sellers attracted a considerable amount of our attention. We have shown that the expectations of the buyers over the whole range of prices are definitely price elastic. Given this price elasticity of expectations, we have then proved that once a disturbance occurs it is sufficient to create circularity in the tankship markets to perpetuity. The oil companies will rush into the market to secure an increasing share of the existing tonnage, adding further impetus to rate increases. The manifestation of an increase in tonnage demand will be further magnified in the spot market, because only an average of 15%--less during periods of high rates--of the total tonnage operates in the spot market. Thus a 1.66% increase in demand for tonnage comprises at least 11% of the spot capacity.

Orders for new vessels will be initiated by expectations during periods of rising rates and will only stop when rates start declining. This relationship implies evidences of surpluses--leftward shifts in demand--even before the deliveries start appearing in the markets; but even excluding such a possibility, the deliveries will eventually shift the supply schedule to the right and depress the rates. That is, the downturn will occur even if the demand schedule does not shift to the left.

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1 Surpluses may occur before new vessel deliveries start, for four main reasons. The first three of these reasons operate through the demand, and the fourth through the supply. (a) The expectations may turn inelastic and thus effectively shift the demand schedule to the left. (b) Usually, many of the transactions are completed for future delivery (the lead time increases with the rates). If such transactions are purely anticipatory or speculative, then surpluses will become evident as soon as the ships are turned over to the charterers. (c) The chartering activity may serve as a "catharsis" of impulses. After the buyers exhaust a lot of energy by ordering, they may see the transparency of their expectations and so withdraw from the market. (d) The impact of short-selling may be enough to shift the supply schedule to the right and precipitate a downfall in rates.
The elasticity of the lower part of the supply schedule is nearly infinite. Consequently, rates will reach the lay-up point of the marginal vessel very fast, and the continuous inflow of new tonnage will cause extensive lay-ups. The latter will guarantee that rates will remain depressed until either the demand catches up with the available capacity or the excess supply disappears through attrition.

Because orders are placed mostly during periods of high rates, they will create irregular but continuous discontinuities in the attrition rate and will probably also create continuously discontinuous shortages. With elastic expectations, shifts in demand will further accentuate the amplitude as well as the duration of the rate cycle unless these shifts occur at a time of shortages.

The shape of the short-term supply schedule provides evidence that rate stability and equilibria in the short run may be possible only at the lower (elastic) part of the schedule. It is true that extremely short-lived equilibria may occur at any rate, but are so unstable, because of the expectations that operate in these regions, that one wonders whether they merit the name. Only at the bottom of rates does some certainty finally prevail, as evidenced by the number of tie-ups. Everywhere else we expect to observe extensive fluctuations. Equilibria at low rates are possible only because both the normal short-term and the market supply schedules are infinitely elastic.

The position of the tankship supply and demand schedules is also affected by other circularities of shorter duration, such as seasonal trade, repairs and the individual needs of big users. These fluctuations will in effect give an irregularly wavy appearance to the surface of the bigger rate
cycle, as shown in Figure 30. This raises the question of whether any equilibria exist with so many overlapping fluctuations. Well, this is a matter of taste, but it seems to be more in line with traditional theory if the answer is no. In our opinion, since the fluctuations at low rates are persistent and occur within narrow ranges of definable levels (the lay-up rates of the marginal capacity), these levels qualify as short-term equilibria. Thus, there is no one equilibrium but a definable range within which these may be found at low rates. No similar range can be observed during periods of excess demand.

Is there anything that we can say about the intermediate or long run? Do we expect to observe any equilibria? To answer these questions we must analyze the short-run "adjustment paths" over two consecutive production periods. If we find that there is a tendency for repetition, then what applies to the short run must apply to the long run also. That is, if the adjustments show no tendency in the short run--any short run--to approach the relevant long-run (static) equilibrium, then there exists long-run instability.

The reader may already have observed similarities between the tankship markets and the classical cobweb theorem. For example, we have, as in the classical theorem, perpetual naiveté, and adaptive expectations in accordance with existing prices.

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As Akerman has shown geometrically and Nerlove analytically, with adaptive expectations, the following constitutes a necessary and sufficient condition for a return to equilibrium after a disturbance.

\[ (1-2/a) < s/d < 1 \]

where "a" stands for either the coefficient of expectations or adjustment (and is \(0 < a \leq 1\)), "s" for the slope of the supply schedule, and "d" for the slope of the demand. For \(a = 1\) the above formulation reduces to the traditional cobweb conditions of convergence.

Let us stress that whether we are attempting to observe short-run or long-run cobweb reactions, we must concentrate on studying the normal short-term and market supply schedules. It is true that for long-run purposes the relevant short-term supply schedules will be farther to the right because of "permanent" capacity increases. Nevertheless, any oscillations around an alleged equilibrium point must meet the short-term schedules first, regardless of total capacity. The previous argument may not be relevant in the theoretical cases of instantaneous adjustments of the supply schedules, but it is definitely of vital importance to empirical reality with supply irreversibilities.

If we apply the above mentioned cobweb condition to our case, "a" will have to be greater than unity and will show that the values of \(s/d\) for which the oscillations converge are confined between -1 and 1. Such conditions could only be satisfied if the slope of our short-term supply

\[ \text{\footnote{Akerman, op. cit., p. 152.}} \]

\[ \text{\footnote{Nerlove, op. cit., pp. 233 and 236.}} \]
schedule were uniformly inelastic. The infinite elasticity of the lower part, below full capacity, would render our system unstable unless the market supply schedule is likewise infinitely elastic. In addition, we have the complications generated by changes in the slope of our effective demand schedule. On the basis of the cobweb criteria of convergence, therefore, no definite conclusion can be drawn regarding the stability of the tankship market equilibria.

In order that the traditional cobweb assumption apply to the tankship markets, we must further make the following qualification:

1. Pure Competition

Underlying the cobweb oscillations is the assumption that the "producers" behave as pure competitors. Their output is determined by "present" prices and the belief that such prices will continue. Furthermore, each "producer" decides independently, not realizing his interdependence on the decision of others or the effect his output will have on the market. In the tankship transportation market we do not have the ideal competitive conditions, as the efforts of the oil companies to reduce their dependence on the independents evidence. We have previously pointed out that the tankship transportation markets behave in a near perfectly competitive manner not because of the existence of all the pre-conditions of perfect competition, but in spite of several aspects of the institutional environment. What we observe in the tankship markets is a paradox. Also, the price expectations operating in the tankship markets are not exactly identical to those inherent in the cobweb assumption of uniformity, because in our case we have observed a certain degree of asymmetry in the behavior of buyers and sellers. Furthermore, we have argued that even a manifested complete symmetry in expectations may not necessarily imply that the sellers have in reality price-elastic expectations, but that they may react rationally to the elastic
expectations of the buyers. Empirical evidence shows that the independents are motivated by a mixture of the above hypotheses, and that the expectations of sellers are price-elastic over certain price ranges.

To the extent that a lot of orders for new vessels are placed only after a contractual agreement between oil companies and independents is entered (that is to say a signed charter), pure independence of supply and demand is not preserved. There is a certain amount of "coupling" of partial behavior. In spite of this partial interdependence of supply and demand, however, the pattern of orders placed during rising rates leaves little doubt that the greatest part of each "new" supply is initiated without regard to overall interdependencies. Especially little heed is paid by any one buyer or seller to the interdependences between his actions and those of the remaining buyers and sellers in the industry. In fact a number of new sellers enter into the market during periods of high rates. Had they realized their mutual interdependence the new sellers would not have entered into the market at that time, and the existing sellers would not have placed orders for vessels. Having obtained the charter they should have waited for the downturn to buy existing vessels that go begging for business. The same arguments can be made even more strongly concerning the behavior of buyers.

2. Reversibility of Supply

The cobweb theorem assumes that the supply schedule remains unchanged, implying complete reversibility and perfect adaptability during contractions, without any complications arising from any "reserve" capacity caused by previous expansions.¹ Unlike such assumptions of complete perishability of capacity (i.e., that the investment in one period will not benefit or influence the capacity or output of another period), the supply schedule of

tankship transportation is irreversible and as a result prior mistakes carry into the future.¹

3. **Infinite Inelasticity of the Market Supply Schedule**

Although this assumption is not explicitly stated, it is implied in the assumption of output perishability. In modifications of the original cobweb theorem that mention "stocks,"² the market supply schedule is still depicted as very inelastic at all levels, with the exception of some deviations to the left from the vertical, because of replenishment and perhaps some speculative enlargement of stocks.³ Such assumptions imply zero storage cost, but because the present price is expected to govern in the future, everyone prefers to sell at once instead of store for future sale. Only at a price equal to zero does the market supply schedule become infinitely elastic. Contrary to the above assumptions, in the tankship markets, expectations over a period of intermediate and long-run duration are rate inelastic under depressed conditions, even though they are elastic over the short run. The cost of tie-up also sets a positive lower limit below which rates do not go under normal circumstances; hence the market supply schedule becomes infinitely elastic much before reaching zero and thus confines the fluctuations.

4. **Point versus Continuous Input and Output**

The markets that have been traditionally associated with cobweb phenomena are related to agriculture, and for good reasons:

(a) The productive processes in agriculture are usually initiated at the same time and do not require continuous input. This is important because cancellations would otherwise occur.

¹ Akerman has made a distinction between the long-term normal supply, short-term normal supply, and market supply curve. He did not assume complete intra-period reversibility, but his emphasis on the normal long-run schedule betrays an assumption of complete interperiod adaptability. See Akerman, *op. cit.*, pp. 151-152.

² Akerman and Nerlove, *op. cit.*

³ Akerman *op. cit.* p. 152.
(b) The initiated agricultural production all matures at approximately the same time, thus preventing any "successive quantitative adaptations."

In the tankship markets, orders are placed as a result of rates, but both the capital inputs and the output are continuous. The penalties of cancellation are usually heavy—if construction is far along—so cancellations may be discouraged. As a result, the total output initiated by a period of high prices may not be affected very substantially by subsequent events. However, all vessels ordered are not expected to be completed at the same time, because of the different processes applied by the different shipyards and also because of the intentional prolongation of many contracts after a decline in rates.

The differences between agriculture and other industrial production, which we have just expounded, led Akerman to state that the cobweb reasoning applies outside of agriculture only to a very limited degree. In his words, other processes "are started and consequently come to an end at different successive points of time and are in that way open to successive quantitative modifications."¹

Because of the above mentioned irreversibilities and the absence of a definite "production period,"² the static long-run equilibrium of tanker rates, if any, around which oscillations occur will be continuously changing as new capacity becomes available. This new capacity, as we have

¹Ibid., p. 160.

²The duration of the so-called "production period" is positively related to the intensity of the original impact, implying that there exists no uniformity between the duration of the various rate cycles.
previously shown, will continuously flow in, but will reach its peak between two to three years after the decline in rates. Thus, new long-run static equilibria will be created continuously, and oscillations will have an altogether different point of reference all the time.

Another and very important conclusion that we can derive from the above is the simultaneous existence of cobwebs of different duration. While the main center of gravity is the relevant static long-run equilibrium, the oscillations around such a point are spun by smaller cobwebs, and even if it remains constant. These movements are similar to those of the solar system. The sun, like the static long-run equilibrium, is the center of "the universe," with planets spinning around it and satellites orbiting around the planets. The latter, like the strings of the cobweb, are sometimes closer to the sun but never reach it.

In summary, the above qualifications modify but do not completely destroy the applicability of the cobweb theorem to the tankship transportation market. We shall now show geometrically the impact of the cobweb interactions on the supply of tankship capacity and the formation of tanker rates.

Figure 31 shows a demand schedule exhibiting the impact of inter-period substitutions caused by price-elastic expectations, and with tanker rates resting at an imaginary equilibrium point "a." Suddenly the demand shifts to the right and there is an excess demand. The spot rate climbs upward

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1 The lower part of the demand schedule is exaggerated for illustrative purposes.

2 A real shift in demand is not required for bringing about an increase in rates and cobweb interactions. A temporary market shortage may jolt the equilibrium and, depending on its intensity, may initiate cobweb oscillations.
FIGURE 31

Cobweb Adjustment Paths
to point b, b' or b" depending on how severe a shock was created by the original shift; for this reason some fluctuations may occur between points b and b".

This increase in rates affects the expectations of the oil companies and the independents, who respond by initiating orders for new vessels. At the same time, the chartering activity is accelerated because of elastic rate expectations, thus possibly causing further shifts in the demand schedule.

The upper limit of rates will be defined by that rate which will absorb all the profit that is imputed to production.\textsuperscript{1} At this point the income-

\textsuperscript{1}Given that the distance of the main market from the alternative sources of supply is not equal, then the rate corresponding to this turning point should theoretically be equal to the value of the nearest oil in the market of price equalization, plus the opportunity cost of refinery shut-downs (or loss of goodwill) and minus the marginal cost of crude production. It is amazing that there exists so much similarity between the turning points of the two rate cycles studied. One gets the feeling that behind this must be some objective reason, but the author has not succeeded in uncovering it. The only positive statement that we can make is the following. During the Suez Canal crisis the critical market was Europe, and that is where the point of equalization must have shifted in order to attract the oil from the Western Hemisphere. The Caribbean oil with AFRA transportation was approximately $4.17 per barrel in the London market (i.e., \$1.17 for transportation plus \$3.00). Whether by coincidence or functional relationship, the average spot cost of transportation for the Persian Gulf crude was \$4.18, but some transactions went as high as \$4.64. One may question the use of AFRA for purposes of marginal economic analysis, since it is a weighted average rate of all existing contracts both spot and long-term (the company-owned vessels are multiplied by the average rate of the long-term contracts). Nevertheless, it is used in industry for long-term agreements as an indicator of the cost of transportation, so it must influence decision-making.

If a functional relation does exist between the cost of transportation from the Persian Gulf and the "delivered" price of the Caribbean oil, then it appears that the marginal imputation of value to the Persian Gulf oil was close to zero. Actually under our assumption it was equal to the opportunity cost of refinery shut-downs and loss of goodwill.
effect, because of the new charters, will become negative and counterbalance the positive inter-period substitution effect that was initiated by price-elastic expectations. Whether the expectations of the oil companies change from elastic to inelastic when the income effect becomes negative is immaterial, but it is a little unreasonable to exclude this possibility completely. To repeat, however, such an assumption is not necessary for our conclusions.

Once up there, the spot rate will remain temporarily at high levels until one of the following possibilities occurs: (a) the supply schedule may shift to the right, (b) the demand may shift to the left, because of a change in expectations, or (c) the demand schedule may be irreversible in which case the withdrawal of the buyers, because of the income effect, will automatically and promptly cause a serious precipitation in prices.

All three of the above have their merits and in fact may be operating at the same time. The last two will undoubtedly bring about a faster reaction. Of these two, empirical evidence gives credence to the irreversibility of the demand schedule, with price-elastic expectations still operating. That is why the decline occurs so swiftly. Because once it starts, with price-elastic expectations, it cannot stop until the bottom is reached.

Let us now suppose that the demand does not shift, that the demand schedule is reversible, and that all depends on the supply schedule. We assume this because we wish to show the independence of our arguments from demand considerations.

The supply schedule may shift for one of the following reasons:
1. The vessels ordered because of the high spot rates will eventually be delivered and thus increase the capacity available.

2. Capacity may be "effectively" increased by short-chartering for future delivery.

The response of deliveries to high rates will be immediate, but at first not significant, because of the time it takes to build a vessel; it may be six months to a year before the impact of the new deliveries is felt. Chartering for future delivery, however, does satisfy needs immediately, because the greatest part of such needs is only psychological and not real, extended and not immediate.

The shifts in supply, for the above reasons, will create slight downward pressure on rates and fluctuations at points such as c, d, and e; and finally the slightest addition to actual or effective capacity will send the rates sliding downward to point f. These downward movements in rates usually follow the market-supply schedule. Consequently, the rates may reach a lower point than that indicated by the normal short-term schedule at the same quantity. The slight slope is given these market-supply schedules to indicate some withdrawal from the market, either for real or purely speculative reasons. Also the slope of the price path (upward) is given a slight positive slant to indicate some enlargement of capacity due to speculative recommissioning of vessels.

For industries such as ship operation in which economies of scale are still realized, the normal long-term as well as the normal short-term supply schedules will shift, but because these shifts will only affect the level and not the quality of the cobweb adjustments, we leave them out.
Let us now observe how rates fluctuate during periods of surpluses. These fluctuations will occur between the static long-run equilibrium and the refusal rate of the marginal vessel. Because of the low rates at point \( f \), the quantity offered in the market drops to \( g \), following the short-term schedule through long-run point \( V \). This decrease is due to the shift from the market supply to the normal short-term schedule. At this point we will assume for purely illustrative purposes that all the vessels are still in the market and that the short-run supply schedule remains unaltered for a while. With quantity offered at such low rates, the latter may be bid up to level \( h \), which brings forth quantity \( i \), depressing the rates again to level \( j \).

Seeing that rates are very low and the prospects for improvement dull, some owners may get discouraged and decide to tie up their vessels. This means that quantities \( k' \) and \( k'' \) instead of \( k \) are offered at that rate level, and active capacity is shifted to the short-term schedule running through the static long-run capacity point \( III \). The cobweb now will gravitate upward, fluctuating successively through points \( l, m, \) and \( n \). Some of the capacity that has been previously tied-up, if it has not been permanently retired, may be encouraged by relatively higher rates and come out of tie-up, causing a shift to another short-term supply schedule corresponding to a new long-run static capacity point such as \( IV \). So the cobweb is spun through points such as \( l', p', q' \).

These movements up and down the lower part of the demand schedule will continue, but will be confined entirely below the long-run supply schedule, as long as excess capacity exists to be enticed when rates are high and discouraged (tied up) when rates are low. Finally, and even without
rightward shifts in demand, attrition, through permanent retirements, will exhaust all the "reserve" capacity, and the cobweb will follow points similar to p, q, r, s spinning to the left. One of these leftward movements will go past the relevant demand schedule and then a new "production cycle" begins.

Notice that the static long-run equilibrium, even with assumptions of demand stability, has been approached but never reached, except incidentally. In actuality, because it takes so long for the rate to rise above the doldrums of the lay-up point, we do expect changes in the relevant long-term equilibrium point. Hence "the long'run" equilibrium is unstable.¹

In conclusion, we have found that oscillations are characteristic of the tankship markets. These oscillations are confined, having as a lower boundary the refusal rate of the marginal vessel, and as an upper boundary the price at which the income effect becomes negative and sufficiently large to counterbalance the inter-period substitution effect. (At this point the market may also get a gratuitous jolt from a concomitant but unnecessary change in expectations). Stability of equilibria at a rate higher than the full cost of the most marginal vessel is inconceivable because of the impact of rates on orders placed. Even without any other influence, the shifts in supply initiated by the high rates will cause a rate downfall.

Under depressed market conditions the rates will be bound by the "lay-up rate" of the marginal vessels, and the short-run cobweb-like oscillations will be converging toward some short-run equilibrium point. The slopes of the short-term and market supply schedules guarantee such convergences.

¹See Baumol, op. cit., p. 114, for a comment on this point.
Because of the tie-up and recommissioning of vessels, the relevant short-run equilibria and their corresponding static long-run equilibria will be shifting from left to right and vice versa, confining the oscillations in rates within a relatively narrow range. The latter is due mainly to the quick response of the owners to the rate movements, and to their ability to respond quickly. Eventually, however, the readily available excess capacity will either be in use or retired. As a result, rates will approach the static long-run equilibrium, swiftly go beyond (to the left), and start another rate cycle.

The rates, therefore, will finally approach the relevant static long-run equilibrium point but will not stay there. This conclusion and the fact that the position of such equilibria changes indicate that the tankship markets are in the long run unstable.

Let us explore an apparent inconsistency between the following two statements that we have made:

1. That there is a convergence toward short-run equilibria, under depressed rates.

2. That the static long-run equilibrium is approached but the system is unstable in the long run.

First of all, we must remember that there are cobweb cycles of different durations and what we called "suns," "planets," and "satellites." Because of the shifts in these short-term equilibria, the short-term cobwebs continue ad infinitum. Nevertheless, the oscillations around any one fixed short-term equilibrium are converging. Because the fixity of the relevant short-term schedules is transitory, as vessels are activated and reactivated,
the convergence will continuously have a different point of reference. The area within which these potential short-term equilibria exist is on the lower part of the demand schedule, it is well defined and predetermined by the capacity available and the reaction patterns of the suppliers. We cannot, however, say the same thing about the long-run equilibria. As a consequence of the convergence of the short-term cobweb movements under depressed market conditions, we can only concede that a static long-run equilibrium must be approached from below. Why? Because these points of convergence, including some long-run equilibrium, are all located on the same demand schedule if we assume no shifts and a well defined demand.

We cannot therefore even purely as a matter of preference, refer to these short-term points of convergence as stable short-term equilibria, nor can we concede that the static long-run equilibria are stable from below. Because even though the long-run equilibria are approached from below they are bypassed very swiftly. As soon as we step above, the wide fluctuations in rates and the production cycle start all over again. What guarantees that the rate will not be confined below the static long-run equilibrium? The natural attrition of capacity and any of the seasonal or other short-term occasions of excess demand\(^1\) assures us that it will not.

Thus we have shown that the static long-run equilibria are at most stable from below but not from above and because of this the system is unstable, implying that the turning point in expectations and demand occurs very close to the static long-run equilibrium near the full cost of the marginal unit, and is in complete agreement with the empirical evidence we have presented previously.

\(^1\)We may possibly get an egg to stand on its head, but with the slightest disturbance it will topple over.
It is inherent in the system that rates linger at low levels most of the time over the life of a vessel. What, then, encourages investment in the industry? Really, the outlook is not so glum for several reasons.

1. The deviations of the rate from the full cost of the marginal vessel are greater on the upswing than the downswing. During the 1954-1958 cycle, the peak was approximately 350% of the estimated full cost of a T-2, while the trough was only 50%. This indicates that each month of operation at rates corresponding to the peak can offset five months of operation at "rock bottom" rates.

2. We have shown that the lowest rate will be set by the lay-up point of the marginal vessel. Thus with the prevailing rates, all the other vessels—to the extent that their cost of operation is lower—will not only cover their out-of-pocket costs, but also part of all their fixed costs. We will later provide evidence that the economies of scale made possible by progress in the technology of shipbuilding and other ancillary industries are quite substantial and are still accruing. Thus the marginal vessel of today was not the marginal vessel of yesterday, and was able therefore to secure full-cost-remunerative employment over most of its life.

The above arguments point, however, that once all the technological economies of scale, external to as well as internal in the industry, are reaped and the industry reaches maturity, the period of depressed rates will become quite critical for all the vessels operating in the spot market. Conceivably, however,

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1. Because of the infinite inelasticity of the short-term supply schedule beyond full capacity and the fact that yearly shipbuilding capacity is at least seven million DWT. (approximately 15% of existing capacity), the boom is not expected to last more than six to twelve months under normal conditions.

2. Under assumptions of complete certainty and stability, there will be no need for a spot market.
the behavior of the operatives in an industry is conditioned by the dynamic prospects of the industry itself. If this hypothesis is true, and there are reasons to believe that it is, then once an industry exhausts all of its economies of scale and reaches its ultimate stage of maturity (stationary state), the expectations prevailing in the industry may no longer be rate elastic.

3. The average capacity trading in the spot market is approximately 15% of the total and is composed of either the inefficient vessels or the speculative ownership of big tanker operators whose vessels are for the most part on long-term charters. So the impact of short-term rates is felt directly by only a small share of the total market. Those vessels that operate in the spot market at any moment of time must have operated or will operate under at least one long-term charter agreement over their life span. As a result their owners may have had or will have opportunities for recovering their investment in these ships. The vessels that seek long-term employment will only be affected if the long-term rates are sensitive to the short-term levels. To this topic, however, we will return a little later.

It is mainly for the above reasons that we believe the lot of the tanker owners is not so bad in general, even though the spot rate may on the average be below the long-run average cost of a vessel over its life span.

Some Further Empirical Observations Regarding Short-term Rates

We have seen in the various figures depicting short-term rates, the time profile of the rate movements. The empirical observations corroborate fully the inferences drawn from our theoretical formulations and which are shown graphically in Figures 30 and 31.
The spot rates, over the ten-year period that we examined, range from a low of 58 cents to a high of $4.49 per 1,000 ton-miles of oil carried. These rates are expressed in monthly averages, and reached their highest point in February 1957 and their lowest in July of 1954. The rise as well as the decline in rates occur very swiftly, as both theoretical and empirical evidence show. Of the two parts of the rate cycle, the upward climb will be slower because of the tortuous approach toward the normal static long-run equilibrium point. Once the excess capacity is eliminated and the static long-run equilibrium point is bypassed, then the climb picks up speed. The distance to be covered, however, is shorter on the upswing because of the existence of temporary intermediate equilibria. In contrast, during a rate decline the spot rate slides on the market supply schedule and drops all the way to the refusal rate of the marginal vessels. Taking the 1954-1958 cycle, which had a single peak, and adjusting for normal seasonal rate variations, we find that it took 14 months for the spot rates to reach their peak. We also observe that once the full cost of the marginal vessel is reached (around $1.30 per 1,000 ton-miles) then the changes in the level of spot rates become wider, often causing rates to double in a matter of two months. During the decline, rates dropped to 19% of their peak level in only three months, and reached the marginal cost (about 90 cents per 1,000 ton-miles) of a T-2.

1Since the lowest rate reached after the Suez crisis was 61 cents during April, May and June 1958, the bottom of the depression may not have been reached as yet. Given economies of scale and changes in the size composition of the fleet, we would expect the rate to reach a lower level than the 58 cents of July 1954.

2The various phases of the Korean war compounded the cycles and did not allow the first one to be completed in the middle of 1951.
If we analyze the 119 monthly variations in the average spot rates for the years 1949 through 1958, we find that 49.2% of all differences were positive and 50.8% were negative. This uniform distribution of first differences at first glance may be attributed to the presence of a random walk, which would negate our theory concerning a systematic influence of price-elastic expectations. A deeper analysis shows that a random walk is not present.

By developing a transition probability matrix, we find that the probability is .61 that a positive change will be followed by another positive change, and only .39 that a positive change will be followed by a negative change. Given a negative change, then the probability is .605 that the following change will also be negative and only .395 that it will be positive. The symmetry between the two sets of probabilities should be expected because the number of positive and negative changes is uniformly distributed. What is important is the significant difference in the conditional probabilities, implying the existence of price-elastic expectations.

Of all positive differences which followed another positive difference, 38% were of the same magnitude, 29.5% were greater, and 32.5% were smaller than the preceding change. Of the negative changes, 34.3% were of the same magnitude, 31.5% were greater, and 34.3% smaller than the preceding negative change.

In order to ascertain if there is a difference between the changes that occur around the temporary short-run equilibria and those that occur in the regions in which price-elastic expectations operate, we analyzed the changes.

\[1\text{ We define "same" as being within 10 cents, because our probability states were defined by intervals of 10 cents each.}\]
by size. Taking all variations in spot rates, the probability is .49 that a change will be confined within plus or minus 10 cents of the previous rate level. Of these changes 86.3% occurred around the short-run equilibria at low rate levels (around the out-of-pocket cost of the marginal vessel). If we enlarge the price interval a little, we find that the probability is .655 that a change will be confined within plus or minus 20 cents of the previous rate.\footnote{Of all changes, 56.3\% were confined within plus or minus 20 cents having been preceded by a similar change.} Of these changes approximately 86\% occurred around the possible short-run equilibria, and were all preceded by a change not greater than plus or minus 20 cents.

Once a change occurs, either up or down, of a magnitude greater than 20 cents per 1,000 ton-miles, (there are 62 such cases out of 119) then we find that the probability is zero that the following change will be of the same magnitude. What is more, the probability is only .032 that the new rate will be within plus or minus 10 cents of the previous price, given that the previous change was over plus or minus 20 cents per 1,000 ton-miles. Taking the complement of the above probability we see that if an absolute change greater than 20 cents occurs, then 96.8\% of the new changes will be greater than plus or minus 10 cents. The comparable figure for a change greater than plus or minus 20 cents, given a previous change greater than plus or minus 20 cents, is 90.3\%. Coupled with our previous findings that a positive change is followed by another positive change with a probability of .61, and a negative change by another negative change with a probability of .603, the above results show how explosive the rate movements
are until they hit the two reflecting barriers. The latter are represented by the rate at which the negative income-budget effect forces the charterers to withdraw from the market when rates are high, and the withdrawal rate of the marginal vessels when the rates are low.

In addition to the presence of price-elastic expectations, the results presented in this section indicate that the tankship transportation market is very unstable in the long run. The only fluctuations that are confined within a narrow range are those occurring around the short-run equilibria. Even these short-run equilibria, however, are not stable.
Chapter IX

The Long-Term Charter Rate in the Short Run

In trying to find the "quantitative essence" of "the long-term charter rate," one will inevitably be besieged by all sorts of difficulties, intrinsic, expositional, and of detail. The "thing" exchanged for such a rate is not homogeneous, and even if it were, its value would depend on many short-term as well as long-term considerations.

For the above reasons, it may be advisable to separate our discussion of the determination of long-term charter rates into two parts, depending on the duration of the influences that operate on long-term rates. We will find, of course, that many of the factors that affect the long-term charter rate in the short run do likewise in the long run. However, there are distinct qualitative differences in the results of some of these impacts which necessitate such a dichotomy.

In the present chapter, we shall deal with the various factors that affect the long-term charter rates in the short run. Initially, we shall provide theoretical arguments on the qualitative contribution of each one of the relevant parameters, and then we shall proceed to analyze empirical evidence.

1"Long charter rate," as used here, refers to the rate of other than single voyage charters. Later, we will make a distinction between the applicable rates for charters of different long-term durations.
We believe that of all the non-random factors, the following are the most important determinants of the long-term rates in the short run.

1. The short-term rate as of a moment of time.
2. The expectations about the future that short-term rates create.
3. The status of tie-ups at the particular point of time.
4. The level of orders outstanding.
5. The size of the particular vessel.
6. The type of the propulsive system of the vessel (whether steam turbine or diesel).
7. The duration of the charter agreement.
8. The lead-time between the agreement and the delivery of the vessel.
9. The type of cargo carried by the vessel whether "clean" (gasoline and other refined products) or "dirty" (crude oil).
10. The type of currency in which payment is made.

Because some of the above factors, such as the first four, are transient, their impact is expected to be manifested only in the short run. Others are more lasting, however, because their origin lies in objective data and they are therefore expected to appear also in our discussion of the long-run level of the long-term charter rates.

We shall be treating many variables as independent for practical reasons and not because of the existence of functional independence. For example, we have shown in the previous chapters that the short-term rates affect expectations, new orders, and also tie-ups. Accordingly, one may argue that the latter do not qualify as independent variables. This much is conceded. Nevertheless, the impact of short-term rates on orders and
tie-ups, for example, is much more lasting than the level of short-term rates itself; therefore, orders and tie-ups merit individual consideration. For similar reasons, rates of change in certain variables may explain more than the levels, and later we shall test this possibility also.

Let us now take the short-run determinants of long-term rates one by one, and analyze their theoretical impact.

1. The short-term rate is expected to influence the long-term rate both on the upswing and during periods of low spot rates, for reasons similar to those operating in the money markets. Unlike the money market rates, however, as we will see shortly, the long-term tankship rate is expected to be lower than the short-term, under normal conditions.

If we assume certainty and exclude "economies of scale" in long term contracts, the long-term rate would be approximately equal to the arithmetic average of the current spot rate and the expected spot rates over the interval covered by the long-term contract. For this reason alone, it is obvious that the long-term rate will not fluctuate as much as the short-term rate and that at any moment of time, short-term and long-term rates will be equal only if the expected average value of the future short-term rates, properly discounted, is equal to the current spot rate.

If we now remove the aforementioned restrictive assumptions, we notice that differences may arise between long-term and short-term rates for any one or a combination of the following reasons.

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2See Hicks, op. cit., p. 145. The relation will only be approximate because of the time shape of the spot rates over a given interval.
(a) There may be demand uncertainties and expectations over the period covered by the long-term contract. Thus if the current spot rates are considered excessively high, the long-term rates will be lower than the short-term rates, and vice versa.

(b) Because of the risks inherent in the operations of the spot market, the short-term rate will normally be higher than the long-term rate. These risks, unlike those in the money markets, are not due to fears of default, but mainly to fears of unemployment. As we have previously explained, the oil companies resort to the spot market for their marginal needs in order to minimize the amount of idle tonnage. To lure tankships to the spot market, however, the charterers must offer higher rates to compensate the speculators for the risks transferred to them. And, incidentally, the premium of the short-term over the long-term rate must be sufficient to attract the marginal speculator and must make it worthwhile for the most inefficient vessels in the spot market to stay in operation.

(c) Even if we exclude the risk of unemployment, it is logical to assume that there is some subjective value to the certainty of plans. If this is true, then the short-term rate must be higher than the long-term rate by an amount that will compensate the marginal entrant into the spot market for the trouble of entering into frequent negotiations. Conceivably this "trouble premium" could be smaller for the big tankship owners, because they can enter the market and make coincidental agreements of long-term and short-term duration.

(d) In addition to the "trouble premium," the long-term contracts save on time spent for decision-making and are administratively more simple and less costly for both the charterer and the owner. The brokerage fee, which is usually paid by the owners, contributes to the savings that accrue with long-term contracts, even though it is a flat percentage on the total contractual consideration. To the extent that under a single voyage charter the owner pays for the fuel, canal tolls, port and pilot charges, etc., which the
charterers pay under a time charter, the brokerage fee will be relatively higher for vessels trading in the spot market. Furthermore, the brokerage fee sometimes rises from a normal rate of 1 1/4 to 2 1/2% of the contract price because of multiple listings that are necessary under depressed market conditions.

(e) Finally, and an important consideration, there is a real money value to a long-term charter, in that it can be mortgaged. Many independents follow this practice of financing because they save on interest. In cognizance of the security behind a long-term charter agreement, the banks are not only more willing to lend money on two signatures (one of which is that of a secure oil company) rather than one, but also make concessions in the interest rate commensurate with the reduction in risk.

In summary, the long-term rates are expected to move in the same direction as the short-term rates but will not exhibit the erratic fluctuations of the spot rates. For subjective and objective reasons, mainly the latter, the short-term rate is expected to be sufficiently higher than the long-term rate to induce the marginal speculators and marginal vessels to stay in the spot market. Somehow the speculators must be compensated for the risk they undertake and which risk of unemployment is shifted to the spot market by the oil companies. Only during periods of depressed market conditions may the long-term rate be higher than the short-term, but because the spot-rate fluctuations are so narrow under such circumstances, the difference between spot and long-term rates will not be great.

2. As we have previously argued, the expectations of the "buyers" in the tankship markets are overall price elastic. This implies that the short-term rates will affect the long-term rates indirectly, through
expectations. It is only logical to assume that if a buyer expects the short-term rates to increase in the future proportionately more than the present rate increase, he will also expect future long-term rates to follow in sympathy. In fact the impact of expectations, based on spot rates, may be so great as to distort any correlation between short-term and long-term rates. That is, once the short-term rates generate expectations they may become captives of their own creation.

3. Tie-ups will affect long-term rates, as of a moment of time, because these vessels form a ready reserve on which the charterers may draw. We have shown that as long as this reserve exists, the level of rates cannot improve. Thus, the greater the capacity tied up, the lower the long-term rates will be.

4. Orders are mostly determined by spot rates but are not as transient as rates, because of the shipbuilding lead time. For this reason, high levels of orders outstanding (backlog) are compatible with periods of both high and low rates. When rates are rising, orders rise with them, and the level of orders outstanding as of that moment has no direct adverse impact on the current long-term rates, because of the expectations prevailing. During rate depressions, however, with all the surpluses that are brought about, orders outstanding condition expectations and thus affect "future" rates, especially if many of these vessels do not have charters waiting for them upon completion. In general, however, we would expect to find a positive correlation between total orders outstanding and long-term rates even under depressed market conditions, because with the drop in rates, new orders are no longer placed and the deliveries and the cancellations bring about a reduction in the level of orders outstanding.
5. The size of vessels plays a vital role in the determination of rates because the industry still enjoys internal technological economies of scale. The savings that accrue with size are very substantial, and theoretically should be reflected in both the short-term and the long-term rates. Because of the risks involved in operating large vessels in the spot market, however, not many vessels of the supertanker size are found there under normal conditions. Only during depressed periods are these vessels likely to accept single voyage charters, because under such circumstances their only alternative is tie-up.\(^1\) We have shown, however, that the refusal rate of the marginal block of vessels usually sets the price in a depressed market. Furthermore, inasmuch as many of these large vessels accept employment with "part-cargo" because many spot charterers cannot utilize them at full capacity, the refusal rate of the marginal vessel may not cover much more than the out-of-pocket cost of these supertankers. Consequently, the rates are equalized and the economies of scale are buried in underutilization of capacity during depressed market conditions.

The impact of the economies of scale, then, is felt mostly in the long-term market. We shall now examine the qualitative features of this impact on the rates.

Because it is necessary under conditions of excess demand to raise the level of rates in order to attract vessels of smaller and smaller sizes, the impact of size on long-term rates (as measured by partial correlation coefficients) will be more visible on a high spot market. When rates are

\(^1\)The largest vessel that we observed in the spot market was one of 44,000 DWT., but this was only for one voyage. There may have been, however, other cases of both larger vessels and longer duration which did not come to our attention.
low and most of the smaller vessels are tied up, only the larger vessels are potential entrants into the long-term market; and for this reason alone, the visible influence of size on long-term rates is likely to be small.

6. The economics of tanker propulsion are very complicated, not because of conceptual difficulties but because of the absence of reliable empirical information. With reliable data, the analysis itself would not be different from the one presented in the footnote under "Retirements and Replacements" and in the main text under "Slow-Downs." The available data are not only "colored" and incomplete, but are not even finalized. Because the technology is still rapidly developing, the comparisons between the diesel engines and turbines are particular and not universally applicable. Up to 1957 the diesel engines could not develop more than 15 to 16 thousand shaft-horse-power (SHP.), while turbines could go up to 25,000. This limited the use of diesel to vessels of about 35,000 DWT. With "supercharge" a diesel could be fitted to propel a tanker of 40,000 to 45,000 DWT. Now, however, plans are made for diesels of 25,000 SHP. which if successful, will again bring the diesel engine into competition.

Assuming then that both steam turbines and diesels can be used for any vessel size, let us briefly consider the pros and cons of this confused subject.1

The main advantage of diesel propulsion is that it achieves greater thermal efficiencies, converting a greater percentage of fuel energy into mechanical power at the shaft. It is estimated that the diesel achieves 40% thermal efficiency (it consumes .35 lbs. of fuel per SHP. hour), while the steam turbine converts only 25% into mechanical power (.575 lbs. per SHP. hour).\(^1\)

The above data imply that the diesel consumes about 40% less fuel than a steam turbine of equal output, thus increasing the vessel's carrying capacity by saving on bunker space. However, the total fuel cost may be higher for the diesel vessel, because it uses a distillate (diesel oil) and the steam turbine uses a residual oil.\(^2\) The cost of the diesel oil ranges, depending on the source, from 150% to 180% of the 'Bunker C' fuel oil used by turbines. Furthermore, the diesel engine does not use more than 80% to 85% of the shaft horse power developed,\(^3\) (vs. 100% for the turbine), which implies that a diesel vessel probably cannot achieve the speed of a comparable steam-driven tanker, thus losing some of its capacity advantage.

In addition to differences in the quantity of bunkers and speed, the difference in carrying capacity between the diesel and the steam driven vessel is affected by the following factors, all of which seem to favor the steam turbine.\(^4\)

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\(^2\)A little later we will discuss the case of diesels using heavy fuel oil.

\(^3\)Jung and Ohlsson, *op. cit.*, pp. 536-537.

\(^4\)See page 305.
See Bes, J., *Tanker Chartering and Management*, op. cit., p. 42-43, also Jung and Ohlsson, *op. cit.*, p. 531. Guldberg-Møller dismiss (b) and (c) of the claimed capacity disadvantages of diesel (there may be a conflict of interest here since their firm produces diesels) and conclude that "the advantage of the diesel-engined ship is so enormous that hardly any responsible shipowner can decide in favor of turbine ships without having very pressing reasons for doing so," p. 11. The aforementioned analysis appears to be somewhat biased. In contrast, Jung and Ohlsson say that "the turbine vessel only needs to save a few days a year for loading or discharging or owing to shorter repair times, and it will be economically superior," p. 538. The empirical data that they present show that a steam-driven vessel usually spends 295 days at sea, versus 275 for the diesel (p. 539), which is more than enough to counterbalance the capacity advantage and any fuel economy of the latter. Both articles mentioned assume that the diesels operate on heavy fuel.
(a) Both the weight and the area occupied by diesel installations are greater than those of steam turbines.

(b) The diesel engines are more delicate than the steam turbines and require longer repair times.

(c) Because the diesel vessel uses small auxiliary steam installations for loading and unloading, it is not as efficient at port (turn-around time) as the steam-driven vessel.

The cost of operating a motor ship is greater than that of the steam vessel, because of the following factors:

(a) Higher initial investment, because of the bulkier construction of diesels.

(b) Higher maintenance costs, because of the intricacy of the diesel engine.

(c) Greater crew requirements for the engine room.

(d) Requirements for auxiliary units for heating, loading, and unloading, because steam is not available.

On the basis of the above factors, it appears that the steam turbine is superior to the diesel from the economic point of view. However, many operators prefer diesels because of the controllability of diesel power. The latter, it is claimed, allows better maneuverability and easier steering.

During the last three years, many diesel vessels have been fitted with special equipment that enables them to use heavy residual oils (fuel oil). These special facilities, which supposedly have a ten-year life and are not very costly, are used to pre-heat and purify the fuel. The savings in fuel

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1 The Petroleum Press Service, October 1958, p. 377, claims that the cost is £20,000 - 25,000 while Bes, in his Tanker Chartering and Management, op. cit., p. 42, says that it is £10,000.
cost are of course substantial, but evidently corrosion necessitates frequent replacements of the cylinder liners and piston rings. According to Bes\(^1\) this cost is approximately £2,000 per year.

If the data correspond to the actual costs of conversion, there is no doubt that the converted diesel engine is more economical than the regular diesel. In fact, the whole investment is recovered in one year out of the savings in fuel cost, which are approximately $300 per day on a T-2 size vessel. As for the relationship between the costs of operation for a converted diesel and a geared turbine, it seems that these costs are now equalized for vessels of small sizes, with the diesel a slight favorite.

The above excursion into the economics of diesel versus turbine engines provides us with all the information that we need in order to assess the effect of propulsion on long-term rates. Under a long-term charter agreement the charterer pays for the fuel, port charges, and canal dues, but all the other operating expenses such as crew costs, repairs, and maintenance are the responsibility of the owner. Consequently, if we assume full capacity, the vessels that are most economical in fuel consumption are expected to command a premium, since the savings from fuel consumption will accrue to the charterer.

Because capacity is also affected, the criterion of vessel choice then reduces to fuel cost minimization per unit of capacity, and provided that the opportunity cost of the capacity lost is not greater than the overall savings achieved. This applies only to the region of elastic supply.

\(^{1}\)Ibid., p. 42.
According to the Petroleum Press Service\(^1\) and Bes,\(^2\) the converted diesel vessel has been commanding higher charter rates for the reasons just explained. However, we feel that the regular diesel will not command higher rates than the turbine vessel but, on the contrary, possibly lower.

Data on the categories of the propulsive systems of the particular vessels are available, but unfortunately no information exists on conversions. For this reason this variable will not be used in our formulation explaining the long-term rate.

7. The duration of the charter agreement, as we have explained during our discussion of the relationship between the short-term and the long-term rate, will affect the long-term rate because of:

(a) The uncertainties and expectations concerning the movement in spot rates over the period that the long-term contract covers.

(b) The risks of unemployment that are eliminated by the long-term agreement.

(c) The nuisance of frequent contracts.

(d) The savings in the administrative costs and the brokerage fees.

(e) The mortgagability of the long-term contracts.

Because of the uncertainties in the movement of short-term rates over an extended period of time, it is natural to expect that decisions be made on the basis of deviations from the static long-run costs. This is the only objective criterion available to the owners and will logically serve as a point of departure, especially for those whose imaginative anticipation of future

\(^{1}\)October 1958, issue, p. 378.

\(^{2}\)Tanker Chartering and Management, op. cit., p. 43.
short-term conditions is not very strong. The deviations from this cost-based long-term rate will be determined by the short-term conditions that are expected to prevail, but will grow fainter and fainter as the duration of the charter is extended.

For long-term contracts which do not extend beyond the foreseeable future, the difference between the long-term and the short-term rates will be mainly caused by (a), the expectations concerning the movement in spot rates over the period covered by the contract. This impact is expected to cause long-term rates higher than the "current" short-term rates (but still below the relevant static long-run cost) in periods of excess supply, and lower than the existing short-term rates (but now above static long-run costs) in periods of excess demand. These differences are due to the imaginative anticipation of the turning points and the future levels of rates, on the part of the people who operate in the tankship markets. Furthermore, there are certain aspects of security that force the charterers to yield during periods of low rates and the owners during periods of high rates.

With a long-term contract extending beyond the time period that imagination can penetrate, the influence of factors (b) to (d) will be reflected in the level of long-term rates but will be very small, merely because the imaginative anticipation beyond a period of, let us say, five years will at best be very weak. The mortgagability of the long-erm charter, however, may have definite and discernible influences, which become stronger the longer the duration of the charter, because its value can be translated into a "present worth equivalent," especially in cases where other sources of capital are closed to the vessel owner. Even in this case, however, an extension of the duration of the charter beyond, say, seven years will not benefit the ship
owner, because banks do not, as a matter of policy, grant loans on charters extending beyond five to seven years. The loanable value of a charter, of course may still change because of the charter rate, but not because of the duration of the contract, if the bank expects a repayment out of the net "hire" in a maximum of seven years.

Even though some of the "unilateral" benefits accruing out of long-term contracts apply also to the charterers (for example, the risk of being caught short of capacity, the trouble of entering the market, and the administrative cost saving), the owners still benefit much more than the charterers, and therefore we would expect, under normal conditions most of the savings to be conceded to the oil companies. The bargaining position of the big charterers is strengthened by the fact that they own and control a considerable amount of transportation capacity whenever they enter the market, and as a result, their needs are not as immediate as those of the owners. Whenever the oil companies enter the market for long-term charters of five to ten years, the exact timing of the agreements is rather immaterial because the companies have some flexibility as a result of the capacity they control. For the independent, however, every day of idleness is costly as the incidence of idle costs is not postponable, and he is therefore under more pressure.

The concession of most of the saving of the long-term contracts to the charterers will then cause slight downward shifts to the "current" long-term cost that is used as a guidepost for determining the long-term rate of contracts of different durations. These movements must not be confused with shifts caused in the long run by changes in the composition of the fleet, which we will discuss later. Here we refer to the same static long-run costs but seen successively relative to charters of different duration.
If we now put together the impact of factor (a) with that of factors (b) to (e), the relationship between the short-term and the long-term rates of different durations may appear as shown in Figure 32.

What we call "normal rate" here is nothing more than the hypothetical normal long-term rates based on static long-run costs. The slightly negative slope is due to factors (b) to (e) as previously explained. Factor (a) will cause these transcendental curves to approach the "normal rate" from above and below as the duration of the charter is lengthened.

Theoretically, there is an infinity of such curves corresponding to the infinite number of possible short-term rates. When the spot rate is below the normal long-term rate, the market long-term rate will tend to be greater, the longer the duration of the contract. On the other hand, when the short-term rates are very high, the market long-term rates will be lower, the longer the charter's duration.

Because of the disproportionate fluctuations of the spot rates above versus below the normal (static) long-term rate, the lower part of the previous graph is flatter. Thus we would expect stronger empirical relationships between the market long-term rates and the duration of the charters under high rates. Furthermore, if our theoretical arguments are valid, 

\[1\]

A slightly negative slope may also be caused by anticipations of economies of scale over the life span of the charter agreement. If the charterers expect that even the most efficient of the existing vessels will become rather semiobsolete in a few years, they will undoubtedly discount the benefits to be accrued during the last few years of the charter heavily.

\[2\]
The negative slope of the "asymptote," namely the normal rate, may upset this relationship. The market long-term rate may increase with the duration of the charter up to a certain point and then turn downward, reversing the relationship.

---
\[ Y = z + \frac{b}{x^2} \]
(or \( Y = ce^{-bx} \))

\[ Y = a - \frac{b}{x^2} \]
(or \( Y = -ce^{-bx} \))
the range within which rates for charters of very long duration move must be very narrow, indicating the great degree of independence of the long-term rates from current market conditions.

Although we have been talking in terms of the static long-term rate, we must not forget that there exists considerable heterogeneity in the tankship markets, because vessels are not identical. Their speed may be different, their propulsive system, their pumping capacity and also their construction. All these heterogeneous characteristics, however, can be reduced into homogeneous objective data and can be accounted for in the relationship between size and long-term rates. Once such "quality differentials," are accounted for, then all long-term charter rates for charters of equal time duration are equalized in the market to a very great extent.

The process of translating time charter rates into a homogeneous basis, although manageable, is rather complicated. It requires a conversion of the stated capacity of a vessel into tons of oil that the vessel can potentially deliver and then calculating the cost per ton of delivered oil. Obviously the run will affect the calculations, not only because the longer the run the smaller the potential deliveries, but because for any one vessel the carrying capacity is not a linear function of the distance. The days in port for loading and unloading, and the time spent traversing canals, are mostly fixed per trip, irrespective of the size of the vessel and the distance covered. As a result, one must first choose a run, take the particularities of the vessel and the terms of the transaction, and then calculate the spot rate equivalent of a time charter. An illustration of the method used for converting time charter rates into spot rate equivalent can be found in Appendix II, at the end of this study.
In order to study the relationship between the duration of charter agreements and charter rates, we have converted into spot rate equivalent the rates for all time charters transacted between 1950 and 1961, over 1,000 altogether. For the conversion we used the Curaçao/London/Curaçao run. The empirical evidence fully confirms the inferences that we made on the basis of purely theoretical considerations. Figures 33 and 34 present some of the results, the rest being of similar nature. The trend lines were drawn "free hand" to go through the mid-values of the transactions. With the exception of 1959, during the years depicted in the figures there was a sufficient number of observations to allow generalizations. In 1955 there were 219 time charter agreements, 383 in 1956, 64 in 1957 and 30 in 1959.

As can be seen in Figure 33, during periods of normal or high spot rates, the longer the duration of the contract the lower the rate. Although the rates for a time charter of one year's duration in 1955 and 1956 ranged from Scale plus 25% to Scale plus 140%, yet we see that the ten-year time charters were separated by only 30 points. These results were expected. As we have previously explained the longer the duration of the contract the greater the influence of objective considerations. The difference between the 1959 trend line and the asymptotes approached by the 1955 and 1956 charter rates is due to the change in the composition of the total fleet, which shifted downward the static long-run supply schedule for the industry. The orders generated by the Suez crisis were mostly for vessels of 40,000 DWT. and over and some of these vessels were in operation in 1959.

In order to observe the impact of spot rates on time-charter rates for contracts of different time duration, we separated the 1956 data by quarters. During 1956, rates increased progressively from an average of $1.60 in the
first quarter, to $3.76 per 1,000 ton-miles in the last quarter. This can be inferred also from Figure 33, because the rate for a time charter of one year's duration is not very different from the spot rate. The results shown in Figure 33 confirm very definitely the theoretical schedules of Figure 32, during periods of spot rates higher than normal.¹

The spot rates during 1957 plummeted from a high of $4.49 per 1,000 ton-miles reached in February to a low of 62 cents approached in November. With the exception of the first quarter of the year, the remainder of 1957 was a year of tanker market depression. For this reason, we chose 1957 to illustrate what happens to the time-charter rate as the duration of the charter increases under high and low spot rates. The results are shown in Figure 34. We notice how the two schedules converge toward Scale plus 10%, which happens to be approximately the full cost of a T-2, as the duration of the charter increases to nine years. From then on the schedule under high rates resumes its downward trend more decisively, while the lower schedule reverses itself. The reasons for this behavior of the schedules, for time charters of eleven years and over, are not only of short-term nature (elimination of risks of unemployment, nuisance of frequent contracts, savings of administrative and brokerage costs, and mortgagability of the charter) but also reflect the impact of expectations concerning technological changes. For if the probability is great enough that the chartered vessels will become obsolete during the tenure of the agreement, this expectation will no doubt influence the charter rate. Finally we notice that the slope of the 1957 schedule under low rates is not very steep, because of the narrow range separating the static long-run rate from the short run equilibria under low rates.

¹In terms of the Scale index, the full cost (including financial charges) of a T-2 is approximately Scale plus 10%.
8. Related to the duration of the charter is the lead time, or the period between the signing of the charter agreement and the actual delivery of the vessel. The lead time is expected to affect the long-term rates because of the uncertainty and expectations concerning the short-term rate over the lead-time period. This, as we have already observed, is one of the factors that affect the relationship between the long-term rates and the duration of the charters.  

The correlation between the long-term rates and the lead time is expected to be positive under low spot rates and negative when spot rates are high. This implies that the longer the lead time, the higher the long-term rate will be under depressed market conditions; and the opposite, during periods of strong demand. Again, as in the case of the duration of the charters, the relationship between the lead time and the market long-term rate will be stronger during periods of excess demand because of the greater fluctuation in spot rates on the upswing.

9. The rate should be affected by the type of cargo carried, because of the cost of corrosion. That is why tankers which are intended for clean trade command a premium.  

A detailed analysis of the cost of corrosion is not needed for our purposes.  

Long-term fixtures, unlike single voyages, do not normally

\[1\] Even though the net manifestation of the impacts of lead time and charter duration on long-term rates is similar, some of the reasons behind such impacts are different. For example, the urgency of the charterers' needs attaches penalties to lead times at high rates and premiums during depressed market conditions. No such impact operates through the duration of charters. Furthermore, the longer the lead time, the lower the loan value of the charter while the opposite is usually true with charter duration.

\[2\] The reader who is interested in the problems of corrosion may wish to leaf through the papers presented at the mid-year and annual meetings of the American Petroleum Institute. The latter's Division of Transportation is very active on matters of corrosion protection.
specify the type of cargo, with the exception of a provision that the vessel may not be used for more than three years in clean trade. On the assumption that only about 30% of the tankship capacity is, at any moment of time, carrying gasoline and other products, the necessity for separating the long-term market into clean and dirty trade is obviated, because the clean trade can be fitted into the three-year limit, excluding exceptional cases. The case is different, however, in the spot market, but for single-voyage charters details exist. The brokers' reports listing the spot transactions separate the "clean" from the "dirty" trade, and indicate that there is a differential of approximately 20 Scale points in favor of the tankers operating in the "clean" trade.

10. Finally, the type of currency in which payment is made should also affect the long-term rate. However, this information is not often available. The transactions are mostly in dollars or sterling, but even though the majority of the payments is made in these two currencies, the designation is presumably more indicative of the central markets where the transactions occurred than of the currency of the actual payments.

Therefore, currency, the type of cargo, and the type of propulsion will be left out of the model that we will test empirically in order to quantify the impact of the factors that operate on long-term rates and which we have theoretically analyzed.

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1Bes, *Tanker Chartering and Management*, op. cit., p. 123. Evidently the three-year limit is independent of the time charter duration.
Chapter X

Model of Long-Term Rates

We shall now explain quantitatively the variation in long-term rates by means of a statistical model. In this respect we shall assume that the relationship between rates and the independent variables is linear, if not in the natural at least in the logarithmic form. This assumption, though an oversimplification of what we believe to be a complicated transcendental function, is suggested by the graph depicting the theoretical relationship between short-term, market long-term, and "normal" long-term rates. The model and several variations to it will be tested by means of multiple regression and correlation analysis.¹

Our first analysis covers the period between 1950 and 1957 and depicts long-term rates as a function of nine independent variables as follows:

\[ x_1 = \text{Index of short-term rates (monthly)}. \]
\[ x_2 = \text{Duration of the charter (in months)}. \]
\[ x_3 = \text{Lead time between charter agreement and vessel delivery (in months)}. \]
\[ x_4 = \text{Size of the vessel (in DWT)}. \]
\[ x_5 = \text{Index of short-term "adjustment" (monthly)}. \]
\[ x_6 = \text{Vessels idle as percentage of the working petroleum fleet (monthly)}. \]
\[ x_7 = \text{Index of change in } x_6 \text{ (monthly)}. \]

¹One other analysis of this sort came to our attention and benefited our work. Alvin Karchere of Caltex studied the time charters for tankers for the period of August, 1956, to August, 1957, and kindly furnished the writer with a copy of his "interim report," 11 pp.
\[ x_8 = \text{Orders outstanding as a percentage of the working petroleum fleet (monthly)}. \]

\[ x_9 = \text{Index of change in new orders placed (monthly)}. \]

The index of short-term rates is a weighted index of the average monthly rates per 1,000 ton-miles for the various runs. The weights assigned approximate the average significance of the oil flows, in terms of tankship capacity utilization, during the period of 1950-1957. If we let:

- \( a \) = the average monthly rate per 1,000 ton-miles for the Caribbean/United States run,
- \( b \) = the average monthly rate per 1,000 ton-miles for the Persian Gulf/United States run,
- \( c \) = the average monthly rate per 1,000 ton-miles for the U.S. Gulf/U.S. North of Cape Hatteras run,
- \( d \) = the average monthly rate per 1,000 ton-miles for the Persian Gulf/United Kingdom run,
- \( e \) = the average monthly rate per 1,000 ton-miles for the Caribbean/United Kingdom run,

the index \( x_1 = (3a + 3b + 6c + 8d + 4e)/24 \)

Rates \( b \) and \( d \) have been adjusted for the canal tolls by subtracting 10 cents per 1,000 ton-miles for the Persian Gulf to the United States trade, and 13 cents per 1,000 ton-miles for the Persian Gulf to the United Kingdom trade. The total round-trip toll is approximately 87 1/2 cents per ton of oil carried.

Variables \( x_2, x_3, \) and \( x_4 \) do not need any explanation, but \( x_5 \) does. What we call here the index of short-term "adjustment" is a "smoothed out" function of the short-term rates. Our purpose in introducing this variable is to test whether immediate expectations are shaped by the "current" spot
rates alone, or whether some form of distributed lag operates on expectations. Furthermore, this index may provide us with at least a qualitative indication of the elasticity of expectations.

The method followed in arriving at the index of adjustment is similar to that used in demand analysis when distributed lags are introduced.\(^1\) We shall assume that the charterers condition their behavior by relative changes in the levels of rates, implying an exponential adjustment path.

Let us denote \(A_t\) as the index of actual changes in spot rates between period \(t\) and \(t - 1\), and \(E_t\) as the expected index of the relationship between the spot rates of the same periods. We define

\[
(1) \quad A_t = \frac{R_t}{R_{t-1}},
\]

where \(R_t\) and \(R_{t-1}\) stand for the level of spot rates in periods \(t\) and \(t - 1\) respectively, and

\[
(2) \quad E_{t+1} = A_t + a(E_t - A_t)
\]

The above definitions imply that if \(A_t < 100\) there has been a decrease in rates, and if \(A_t > 100\) there has been an increase. This type of "index" will exclude negative values which may cause us difficulty in a logarithmic formulation.

As for relation (2) it implies that the expected index of change in rates between periods \(t\) and \(t + 1\) is equal to the actual index of change between periods \(t\) and \(t - 1\), plus a factor "a" times the difference between the

---

expected and actual changes between periods \( t \) and \( t - 1 \). In this respect, as long as the actual and expected indices are the same, we assume in effect that the operatives will expect a percentage change in the rates for the next period equal to the one that occurred in the previous period.\(^1\)

Relation (2) is a difference equation, the general solution of which is:

\[
E_{t+1} = \sum_{k=0}^{n} a^k (1-a) A_{t-k}
\]

Alternatively we can arrive at the solution algebraically as follows:

From (2) by rearranging we get

\[
E_{t+1} = (1-a) A_t + aE_t
\]

(3)

but \( E_t = A_{t-1} + a(E_{t-1}-A_{t-1}) \)

\[
E_t = (1-a) A_{t-1} + aE_{t-1}, \text{ and}
\]

(4)

\[
aE_t = a(1-a) A_{t-1} + a E_{t-1}
\]

Hence (3) becomes

\[
E_{t+1} = (1-a) A_t + a(1-a) A_{t-1} + a^2 E_{t-1}
\]

(6) where again

\[
a^2 E_{t-1} = a^2 (1-a) A_{t-2} + a^3 (1-a) A_{t-3} + \ldots + a^n (1-a) A_{t-n},
\]

(7) and substituting in (6) we get finally

\[
E_{t+1} = (1-a) A_t + a(1-a) A_{t-1} + a^2 (1-a) A_{t-2} + a^3 (1-a) A_{t-3} + \ldots + a^n (1-a) A_{t-n}
\]

(8)

If we now substitute for the \( A_i \) the value as given by relation (1) we get:

\[
E_{t+1} = (1-a) \frac{R_t}{R_{t-1}} + a(1-a) \frac{R_{t-1}}{R_{t-2}} + \ldots + a^n (1-a) \frac{R_{t-n}}{R_{t-n-1}}
\]

(9)

\(^1\) See page 324
Alternatively, one may assume that the "percentage rate of change" is measured in terms of a uniform absolute base, be this U.S.M.C., Scale, or any other base. In this case if we assume continuity of our functions our index becomes:

\[ A_t = \frac{R_t}{R_{t-1}} = \frac{e^{nr_t}}{e^{nr_{t-1}}}, \text{ or } \ln A_t = n(r_t - r_{t-1}) \]

The latter may be taken as denoting the actual difference in the percentage rates of change in spot rates between periods \( t \) and \( t - 1 \); because our subdivisions of each period \( t-(t-1) \) may be taken as equal, we have:

\[ \ln A_t = r_t - r_{t-1} \]
Some of the officials of the oil companies we visited spoke about the alleged use of the so-called "50% rule." Those who use it claim that they always cut differences in half, whenever and wherever these arise, and behave as if the adjusted figures are the actual.\(^1\) We will assume as a result, that \(a = .5\), in which case we get:

\[
\begin{align*}
1 - a &= .5 \\
 a(1-a) &= .25 \\
 a^2(1-a) &= .125 \\
 a^3(1-a) &= .0625 \\
 a^4(1-a) &= .03125
\end{align*}
\]

Let us assume for practical purposes that any period whose impact is less than 5% of the combined impact of the periods following it will be insignificant in the shaping of expectations. Hence our index becomes:

\[
E_{t+1} = .50 \frac{R_t}{R_{t-1}} + .25 \frac{R_{t-1}}{R_{t-2}} + .13 \frac{R_{t-2}}{R_{t-3}} + .06 \frac{R_{t-3}}{R_{t-4}}
\]

In addition to the index of short-term adjustment, we will use variables based on idle vessels, orders outstanding, and orders placed, in order to attest the significance of intermediate and somewhat long-term influences on long-term rates.

---

\(^1\)The "50% rule," according to at least one high official of an oil company, is applied also to plans made on the basis of forecasts. One can easily prove that, if such a practice is used by a substantial segment of the industry, their only salvation may be erroneous forecasts in the right direction, of a magnitude equal to twice the would-be actual. Otherwise, if estimates are always correct, by cutting in half their implementation, the rate cycle will be aggravated and the cobweb effects will be even more pronounced. The probability of correct forecasts, however, is not very great, and even in the remote possibility that the "50% rule" is consciously and consistently applied, we do not expect such practices to aggravate the rate cycle further.
We have previously defined the "working petroleum fleet" as the total fleet minus government-owned vessels, special purpose ships, and vessels idle either because of tie-up or for repairs extending beyond thirty days. Variables \( x_6 \) and \( x_8 \) are both based on the working petroleum fleet.

Variables \( x_7 \) and \( x_9 \) are approximations of rates of change and are based on idle capacity and new orders placed, respectively. The rate of change in idle capacity is measured as the ratio of the idle capacity of period \( t \), as a percentage of the working petroleum fleet of period \( t \), to the respective magnitudes of period \( t-1 \). As for \( x_9 \), it represents the ratio of new orders placed in period \( t \), as a percentage of the orders outstanding at the beginning of the period, to the new orders of period \( t-1 \), as a percentage of the orders outstanding at the beginning of \( t-1 \).  

The "universe" that we are about to analyze consists of 1,048 long-term charters--time charters only, not consecutive voyages--which according to the brokers comprise over 95% of all the transactions of the period under observation. Of these 1,048 observations, 129 had to be rejected because they were followed by options for an extension of the contracts, and six more because they were bareboat charters. For certain computer runs an additional sixteen observations were eliminated because they involved vessels under 9,000 DWT tons.

The statistical models that we will discuss were tested at the MIT Computation Center. The preparatory work, excluding the time spent on

1 New orders placed are defined as 1,000 + new orders (all in T-2s) in order to avoid negative numbers due to cancellations.

2 Under a bareboat charter agreement, the owner delivers a "bare" vessel and the charterer has to man it, provide for the crew, etc., as if the vessel were his.

3 We wish to express our appreciation for the use of the computation facilities.

4 Developing the coding instructions, coding, punching, and sample testing the data.
collecting data, consumed over 2,500 man hours; and the processing of the data required about five hours of computer time. The subsequent analysis of the results of course consumed many hours, and some of the implications of our original findings indicated further avenues of research exploration that we are pursuing now.

Believing that there are qualitative differences in the impacts of some of the variables on long-term rates during periods of high and low rates, respectively, we decided to test and see how significant such differences are. We, therefore, separated all long-term transactions into two samples, depending on whether the short-term rate at the time was over or under $1.30 per 1,000 ton-miles, and subjected the long-term rate means to variance analysis. The test shows that we cannot say anything at a critical value of 1% but for 95% confidence level the means of the two samples are definitely different. Because of these results, it was decided to run the data in two samples as highs and lows.

Without exception, every test indicated that the logarithmic formulations were better. This much we did expect from the theoretical discussion presented in the chapter on the long-term rates in the short run. (See especially the discussion on the relationship between the short-term and the market long-term rates and also on the impact of the duration of the charter on long-term rates.) For this reason, we shall present here only the results of the logarithmic regression and correlations, but first we wish to issue this warning. Many of the assumptions on which the mathematical theory of

---

1 This rate was chosen as representing the upper limit of the full cost of a T-2.
correlation is based are at best only approximated by empirical reality. The significance of the results that we shall present lies principally in the qualitative relationships that these results reveal. We shall now proceed with the quantitative evidence.

Table 25 presents the correlation matrix under low rate. The regression equation giving the best fit is:

\[
\ln Y = 5.23 + 0.752 \ln X_1 + 0.004 \ln X_2 + 0.029 \ln X_3 - 0.213 \ln X_4 \\
- 0.550 \ln X_5 + 0.0004 \ln X_6 - 0.195 \ln X_7 + 0.197 \ln X_8 + 0.140 \ln X_9
\]

The correlation coefficient for the above is \( r = 0.644 \), giving a coefficient of determination \( r^2 = 0.415 \) and a standard error of estimate of 0.157.

Theoretically, the coefficients of the above regression equation show the respective elasticities, or the percentage impact on the long-term rates of percentage changes in the variables.

The standard errors of the slope coefficients of the regression equation are:

<table>
<thead>
<tr>
<th></th>
<th>Intercept: 1.116</th>
<th>( X_5 ) 0.181</th>
<th>( X_1 ) 0.131</th>
<th>( X_6 ) 0.109</th>
<th>( X_2 ) 0.011</th>
<th>( X_7 ) 0.049</th>
<th>( X_3 ) 0.009</th>
<th>( X_8 ) 0.028</th>
<th>( X_4 ) 0.030</th>
<th>( X_9 ) 0.056</th>
</tr>
</thead>
</table>

At a critical level of 5% (two tails), the coefficients for \( X_2 \) (duration of the charter) and \( X_6 \) (idle capacity as percentage of the working petroleum fleet) are not significant (are unstable) whereas all the others are highly significant. It is not surprising to find some instability in view of the
# TABLE 25

**Correlation Matrix: Lows: 304 Observations**

<table>
<thead>
<tr>
<th></th>
<th>X₁</th>
<th>X₂</th>
<th>X₃</th>
<th>X₄</th>
<th>X₅</th>
<th>X₆</th>
<th>X₇</th>
<th>X₈</th>
<th>X₉</th>
<th>Y</th>
<th>Significance of (r_{xy}) 95% Confidence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₁</td>
<td>1.000</td>
<td>.125</td>
<td>.106</td>
<td>-.102</td>
<td>.844</td>
<td>-.571</td>
<td>-.594</td>
<td>-.649</td>
<td>-.884</td>
<td>.062</td>
<td>No</td>
</tr>
<tr>
<td>X₂</td>
<td>1.000</td>
<td>.639</td>
<td>.509</td>
<td>-.014</td>
<td>-.108</td>
<td>.051</td>
<td>-.033</td>
<td>-.091</td>
<td>-.010</td>
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<td></td>
</tr>
<tr>
<td>X₃</td>
<td>1.000</td>
<td>.439</td>
<td>-.022</td>
<td>-.030</td>
<td>.076</td>
<td>-.002</td>
<td>-.065</td>
<td>.078</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>X₄</td>
<td>1.000</td>
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<td>-.091</td>
<td>.080</td>
<td>.188</td>
<td>.076</td>
<td>-.164</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>X₅</td>
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<td>-.245</td>
<td>-.626</td>
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<td>-.112</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>X₆</td>
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<td>.151</td>
<td>.611</td>
<td>-.289</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>X₇</td>
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<td>.620</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>X₈</td>
<td>1.000</td>
<td>.571</td>
<td>.299</td>
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<td></td>
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<tr>
<td>X₉</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
high intercorrelation that exists between our independent variables. Such a
correlation between variables, however, should not be taken as necessarily
implying a direct relationship, because any two variables may be influenced
by one or more other variables in such a manner as to give a strong mathe-
several of our variables, and there is a resulting tendency toward some
distortion. There is another reason, however, for the instability of the
coefficient of time-charter duration. As we have shown in Figure 34, there
is a tendency for a reversal in the schedule depicting the relation between
rate and time-charter duration during periods of low spot rates. At first,
the time-charter rate tends to increase as the duration of the charter is
extended, but then it turns downward. We notice that the regression
coefficient is close to zero, and can easily assume a negative sign. As
for idle capacity, again when rates are low in one sense the greater the
number of vessels tied up, the fewer will be available in the spot market
and the greater the probability for employment at somewhat remunerative
levels. Again in this case the regression coefficient is almost zero
showing the presence of conflicting forces.

To assess the relative importance of the coefficients of regression in
determining the dependent variable, we have derived and present in Table 26
the standardized or "beta coefficients." The latter indicate the increase
in the dependent variable resulting from an increase of one standard
deviation variable.\footnote{Arkin, Herbert and Colton, Raymond, Statistical Methods, Barnes and Noble, New York, 1957, pp. 96-97.} Comparing the non-standardized with the beta
Table 26
MULTIPLE REGRESSION COEFFICIENTS AND STANDARD ERRORS

LOWS: 304 OBSERVATIONS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.226</td>
<td>1.116</td>
<td>5.954</td>
<td>1.663</td>
</tr>
<tr>
<td>$x_1$</td>
<td>.752</td>
<td>.131</td>
<td>.824</td>
<td>.144</td>
</tr>
<tr>
<td>$x_2$</td>
<td>.0046</td>
<td>.011</td>
<td>.025</td>
<td>.063</td>
</tr>
<tr>
<td>$x_3$</td>
<td>.029</td>
<td>.009</td>
<td>.188</td>
<td>.060</td>
</tr>
<tr>
<td>$x_4$</td>
<td>-.213</td>
<td>.030</td>
<td>-.398</td>
<td>.056</td>
</tr>
<tr>
<td>$x_5$</td>
<td>-.550</td>
<td>.181</td>
<td>-.571</td>
<td>.188</td>
</tr>
<tr>
<td>$x_6$</td>
<td>.0004</td>
<td>.109</td>
<td>.004</td>
<td>.123</td>
</tr>
<tr>
<td>$x_7$</td>
<td>-.195</td>
<td>.0149</td>
<td>-.391</td>
<td>.097</td>
</tr>
<tr>
<td>$x_8$</td>
<td>.197</td>
<td>.028</td>
<td>.453</td>
<td>.066</td>
</tr>
<tr>
<td>$x_9$</td>
<td>.140</td>
<td>.056</td>
<td>.319</td>
<td>.126</td>
</tr>
</tbody>
</table>

\[
\ln Y = 5.226 + .752 \ln X_1 + .0046 \ln X_2 + .029 \ln X_3 - .213 \ln X_4 - .550 \ln X_5 \\
+ .0004 \ln X_6 - .195 \ln X_7 + .197 \ln X_8 + .140 \ln X_9
\]

\[ r = .644 \]
\[ r^2 = .415 \]

Standard Error of Estimate  .157
coefficients, we notice that the only change in rank occurred between \( X_8 \) and \( X_4 \). Otherwise the results do not present any surprises. The reason for the change in rank between \( X_8 \) and \( X_4 \), is that orders outstanding as a percentage of the working petroleum fleet \( (X_8) \) change considerably during periods of low rates. Reductions in the numerator due to deliveries and cancellations are not fully offset by withdrawals from the working fleet, consequently the coefficient fluctuates within a wide range. This can be seen in Figure 17. As a result the standard deviation of \( X_8 \) is relatively large.

Because of the compensating quantitative adjustments that are reflected in the regression coefficients of a multiple regression equation, it was decided that the zero order correlation coefficients \( r_{yi} \) should be tested for significance. The zero order correlation coefficients\(^1\) indicate the mathematical relationship between two variables, and can be found in Table 25. If we take the data of the column under \( Y \) and test their reliability, we find that we can say with 95% confidence that the first three independent variables are insignificant, the fourth significant, the fifth insignificant, the next three significant, and the last one insignificant.\(^2\) The only reliable relationships that we find under low rates are:

- Size versus Time Charter Rate (negative correlation)
- Idle Capacity versus Time Charter Rate (negative correlation)
- Changes in Idle Capacity versus Time Charter Rate (negative correlation)

\(^1\)These are sometimes called partial correlation coefficients of the first order (non-standardized).

\(^2\)For a standard test see Hoel, *op. cit.*, p. 124.
The Level of Orders Outstanding versus Time Charter Rate (positive correlation)

These results are in complete agreement with what we expected on purely theoretical considerations. Size reflects the economies of scale and, as we have argued before, will be negatively correlated with long-term rates under any circumstances. Idle capacity will of course be small when rates are high and great when rates are low, and the level of orders outstanding will move in the same direction as the rates.

The other coefficients of zero-order correlation, even though insignificant, indicate results in agreement with our predictions. The short-term rates are positively related with the long-term rates, as is the lead-time, the latter because under low rates the normal long-term rate is approached from below. The duration of the charter is negatively correlated with long-term rate indicating that the negative slope of the normal long-term rate schedule may be quite pronounced. The regression coefficient for $X_2$, however, which theoretically indicates in a logarithmic formulation the charter-duration elasticity of long-term rates, is positive, showing the great instability of the relationship.

Another important conclusion may be deduced from the sign of $r_{y5}$ (long-term rates versus adjustment index) if this is also valid during high rates. To the extent that the relationship between the spot rates and the long-term rates is positive and the correlation between the index of

---

1 See the chapter "The Long-Term Rates in the Short-Run."

2 We have explained before that under low spot rates we expect the market long-term rate to increase with the duration of the charter up to a point and then turn downward. The reversal is caused partly by objective savings and partly by anticipations of the impact of technological changes (that are expected to occur during the tenure of the charter) on the cost curves of the industry.
adjustment and the long-term rates is negative, we may conclude that the behavior of the oil companies does not follow a "smoothed out" reaction path based on short-term rates. This may also be seen from the regression coefficients of \( X_1 \) and \( X_5 \), which are +.752 and -.550, respectively.

Finally, the sign of the zero-order correlation coefficient between the change in orders placed and the long-term rates is positive, indicating the impact of elastic expectations on both orders placed and long-term rates.

The relationship between the independent variables and the long-term rates under periods of high rates is given by the following regression equation:

\[
\ln Y = 2.405 + .154 \ln X_1 - .046 \ln X_2 - .063 \ln X_3 - .198 \ln X_4 \\
- .353 \ln X_5 + .030 \ln X_6 - .440 \ln X_7 + .449 \ln X_8 + .657 \ln X_9
\]

The coefficient of correlation \( r \) is .698, the coefficient of determination \( r^2 = .487 \), and the standard error of estimate .233. The latter is higher than .157, the standard error of estimate under low rates; yet the correlation is greater under conditions of excess demand (highs), indicating that the standard deviation of the long-term rates is so much greater under high rates that it more than offsets the difference in standard errors. The

\[1\] As we know, in general, \( r = \sqrt{1 - \frac{S_{y,x}^2}{S_y^2}} \)

where \( S_{y,x} \) is the standard error of estimate or the standard deviation around the line of regression, and \( S_y \) is the standard deviation around the mean value of \( y \). That is, \( r \) measures the improvement in the estimate of a variable due to its relationship with another variable. Therefore, other things being equal, the greater \( S_y \) is, the larger the coefficient of correlation. This does not necessarily imply, of course, that a change in \( S_y \) will not affect \( S_{y,x} \), but there is no reason to expect a proportional change. Failure to realize this relation often leads to misuse and misinterpretation of the importance of the coefficients of correlation.
respective standard deviations (logarithmic-geometric) are .203 under low and .323 under high rates; but again the greater variability of the long-term rates under conditions of excess demand (high) was to be expected on purely theoretical grounds.

The standard errors of the intercept and the slope coefficient are:

<table>
<thead>
<tr>
<th></th>
<th>.503</th>
<th>X_5:</th>
<th>.062</th>
</tr>
</thead>
<tbody>
<tr>
<td>X_1</td>
<td>.030</td>
<td>X_6:</td>
<td>.020</td>
</tr>
<tr>
<td>X_2</td>
<td>.017</td>
<td>X_7:</td>
<td>.066</td>
</tr>
<tr>
<td>X_3</td>
<td>.010</td>
<td>X_8:</td>
<td>.040</td>
</tr>
<tr>
<td>X_4</td>
<td>.027</td>
<td>X_9:</td>
<td>.071</td>
</tr>
</tbody>
</table>

The only one of the regression coefficients that is insignificant at a critical level of 5% (two tails) is X_6, or the variable indicating idle capacity; and again, as in the cases of "lows," the coefficient has the wrong sign. By studying the changes in the coefficients caused by the introduction of new variables, we find that under "highs," X_6 is stable and has the proper sign until X_9 is introduced. Under "lows" its sign is changed by X_7 and its significance completely ruined by X_9. A possible explanation for all this may lie in a curious interrelationship that was accidentally established between X_6 and X_9, by our measurement rules. As can be seen in Tables 25 and 27, the variables X_6 and X_9 are positively correlated. Logic tells us that the relationship should be negative. The positive correlation exists because during low rates deliveries and cancellations reduce X_9; but deliveries also increase the working petroleum fleet. As a result, X_6 is reduced because it is expressed as a percentage of the working petroleum fleet. Evidently the percentage increase in
<table>
<thead>
<tr>
<th></th>
<th>X_1</th>
<th>X_2</th>
<th>X_3</th>
<th>X_4</th>
<th>X_5</th>
<th>X_6</th>
<th>X_7</th>
<th>X_8</th>
<th>X_9</th>
<th>Y</th>
<th>Significance of ( r_{iy} ) 95% Confidence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>X_1 (Short-term Rate)</td>
<td>1.000</td>
<td>.052</td>
<td>.161</td>
<td>-.055</td>
<td>.201</td>
<td>-.052</td>
<td>-.081</td>
<td>.115</td>
<td>.034</td>
<td>.211</td>
<td>Yes</td>
</tr>
<tr>
<td>X_2 (Duration of Charter)</td>
<td>1.000</td>
<td>.509</td>
<td>.475</td>
<td>-.114</td>
<td>.066</td>
<td>.233</td>
<td>-.034</td>
<td>.201</td>
<td>-.312</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X_3 (Lead Time)</td>
<td>1.000</td>
<td>.456</td>
<td>-.115</td>
<td>.062</td>
<td>.129</td>
<td>.087</td>
<td>.106</td>
<td>-.317</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X_4 (Size)</td>
<td>1.000</td>
<td>.022</td>
<td>-.063</td>
<td>.132</td>
<td>.208</td>
<td>.063</td>
<td>-.383</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X_5 (Index of Adjustment)</td>
<td>1.000</td>
<td>-.205</td>
<td>-.551</td>
<td>.104</td>
<td>-.488</td>
<td>-.174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X_6 (Idle Capacity)</td>
<td>1.000</td>
<td>.299</td>
<td>-.457</td>
<td>.146</td>
<td>-.167</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X_7 (Change in X_6)</td>
<td>1.000</td>
<td>-.401</td>
<td>.884</td>
<td>-.043</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>X_8 (Orders Outstanding)</td>
<td>1.000</td>
<td>-.429</td>
<td>.254</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X_9 (Change in Orders Placed)</td>
<td>1.000</td>
<td>.105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>
tie-ups in less than the percentage increase in capacity. During periods of high rates, although new orders may be increasing in an absolute sense, yet because of the high level of orders outstanding they may decrease as a ratio of existing orders. So again here a spurious correlation is established between $X_6$ and $X_9$. Another possible explanation may lie in the existence of lags.

Turning now to the contribution of the independent variables, as shown in Table 27, we find that it is significant at the 95% confidence level for every one but $X_7$. This is not surprising, because under periods of excess demand the level of idle capacity reaches a lower limit and cannot drop much below that.

The relative importance of the various $X_i$ in determining $y$ is shown by the beta coefficients presented in Table 28. The change in orders placed still seems to bear the most significant quantitative impact \(^1\) on the long-term rates, followed by the changes in idle capacity and orders outstanding. The most significant rise in relative importance is in the lead-time coefficient, and the greatest set-back occurred in the index of adjustment, both of which changes are not surprising.

If we now compare the respective $r_{iy}$ of Tables 25 and 27, we notice how much stronger is the relationship between most $X_i$ and the long-term rates under "highs." The short-term rate, with its greater variability above what we previously called the short-term normal equilibrium, pulls the long-term rate with it also and creates greater dispersion above the

\(^1\)Let us stress again that this does not necessarily imply a direct relationship. Orders and idle capacity serve mostly as an objective indicator of "intermediate" expectations. Furthermore, these relationships are only valid within the confines of the multiple regression model.
Table 2.3

MULTIPLE REGRESSION COEFFICIENTS AND STANDARD ERRORS

HIGHS: 593 OBSERVATIONS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.405</td>
<td>.503</td>
<td>3.340</td>
<td>.465</td>
</tr>
<tr>
<td>$x_1$</td>
<td>.154</td>
<td>.030</td>
<td>.172</td>
<td>.033</td>
</tr>
<tr>
<td>$x_2$</td>
<td>-.046</td>
<td>.017</td>
<td>-.099</td>
<td>.037</td>
</tr>
<tr>
<td>$x_3$</td>
<td>-.063</td>
<td>.010</td>
<td>-.214</td>
<td>.037</td>
</tr>
<tr>
<td>$x_4$</td>
<td>-.198</td>
<td>.027</td>
<td>-.279</td>
<td>.038</td>
</tr>
<tr>
<td>$x_5$</td>
<td>-.353</td>
<td>.062</td>
<td>-.218</td>
<td>.039</td>
</tr>
<tr>
<td>$x_6$</td>
<td>.030</td>
<td>.020</td>
<td>.056</td>
<td>.037</td>
</tr>
<tr>
<td>$x_7$</td>
<td>-.440</td>
<td>.066</td>
<td>-.492</td>
<td>.074</td>
</tr>
<tr>
<td>$x_8$</td>
<td>.449</td>
<td>.040</td>
<td>.451</td>
<td>.040</td>
</tr>
<tr>
<td>$x_9$</td>
<td>.657</td>
<td>.071</td>
<td>.676</td>
<td>.073</td>
</tr>
</tbody>
</table>

\[
\ln X = 2.405 + .154 \ln x_1 - .046 \ln x_2 - .063 \ln x_3 - .198 \ln x_4 - .353 \ln x_5 \\
+ .030 \ln x_6 - .440 \ln x_7 + .449 \ln x_8 + .657 \ln x_9
\]

\[
r = .698 \\
r^2 = .487
\]

Standard Error of Estimate = .233
normal long-term rate than below. With this greater dispersion, the theoretical path of the market long-term rates will have to make more pronounced adjustments in order to approach the normal long-term rate from above than from below. This much is indicated not only by $X_{1y}$ but also by $X_{2y}$, $X_{3y}$, and $X_{4y}$. Only the idle capacity and the change in it are stronger under "lows," because idleness, after all, is a characteristic of low rates.

Finally, we notice that the correlation between the index of adjustment and the long-term rates is negative, while that between the short-term and long-term rates is positive. This supports our previous contention that expectations and reactions are not smoothed out; and that the so-called 50% rule, as applied to the whole industry, may be more of myth than reality. Expectations are no doubt price elastic.

**Bimodality and Its Impact:** Frequency distributions of some of the variables indicate the existence of bimodalities. This much is also indicated by an analysis of the means and the standard deviations of the variables.

In order to ascertain the significance of these bimodalities, we have divided the "highs" and "lows" into samples, on the basis of vessel size, duration of charter, and historical time period. These six samples of two sub-samples in each were then subjected to the same multiple regression and correlation analysis as used for the total statistical universe, and also to analysis of covariance. All the tests, with the exception of the subdivision of the "lows" by size, indicated that the means of samples were different at 99% confidence level. The multiple correlation coefficients

---

1 Those who wish to see the theoretical justification of these statements should refer back to Chapter IX.
ranged from a low of .519 to a high of .900, but, beyond these quantitative differences the overall results did not change qualitatively. (The details concerning the samples are found in Table 29.) There are, however, some particular results that the above analysis brought to light which are quite interesting and give additional weight to some of our previous claims. For example:

(1) We have previously argued and also substantiated that under both low and high short-term rates, the long-term rates will be negatively correlated with size. Now we find that for vessels under 30,000 DWT., under depressed market conditions only, the relationship between size and long-term rates is positive.¹ (See Table 30) This we cannot understand unless it is due to the reluctance of the owners to reactivate the larger vessels until the rates are remunerative. As we have pointed out when discussing tie-ups, the part of lay-up costs that varies with time is relatively fixed with respect to size. Consequently, the out-of-pocket lay-up cost per unit of capacity is lower, the larger the vessel and, as a result, the greater the reactivation rate.² It is very difficult to believe, however, that the minimum reactivation rate will increase with size if we consider the economies of scale in tank-ship operation. Another possible explanation of the observed relationship may be the fear of idleness beyond the offered contract. Even though the average cost per unit of capacity is smaller, the larger the vessel, on an absolute basis the cost of idleness in operational readiness is greater. Hence unless the probability is great that the reactivation will be permanent, the owners may leave their vessel in tie-up. In this case again, we do not believe the owners attempt to penetrate that much ahead in the future.

¹We have tested with other subclassifications and found that the turning point occurs between 25,000 and 26,000 DWT.

²The minimum reactivation rate is equal to the out-of-pocket cost of operation per unit of capacity less the out-of-pocket cost of tie-up.
TABLE 29

F. Ratio Tests

1. **Lows by Size:** Mean = 1.125 (in natural log)

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of Observations</th>
<th>r</th>
<th>$r^2$</th>
<th>$\bar{Y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,000-29,999 DWT.</td>
<td>270</td>
<td>.622</td>
<td>.388</td>
<td>1.126</td>
</tr>
<tr>
<td>30,000 and over</td>
<td>26</td>
<td>.902</td>
<td>.814</td>
<td>1.108</td>
</tr>
<tr>
<td>F = .003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hence we say that the means are the **same** with 99% confidence.

2. **Highs by Size:** Mean = 1.378

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of Observations</th>
<th>r</th>
<th>$r^2$</th>
<th>$\bar{Y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,000-29,999 DWT.</td>
<td>450</td>
<td>.677</td>
<td>.458</td>
<td>1.403</td>
</tr>
<tr>
<td>30,000 and over</td>
<td>119</td>
<td>.825</td>
<td>.681</td>
<td>1.280</td>
</tr>
<tr>
<td>F = 11.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The means are **different** at 99% confidence level.

3. **Lows by Charter Duration:** Mean = 1.121

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of Observations</th>
<th>r</th>
<th>$r^2$</th>
<th>$\bar{Y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-59 months</td>
<td>124</td>
<td>.554</td>
<td>.301</td>
<td>1.051</td>
</tr>
<tr>
<td>60 and over</td>
<td>163</td>
<td>.691</td>
<td>.477</td>
<td>1.174</td>
</tr>
<tr>
<td>F = 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The means are **different** at 99% confidence level.

4. **Highs by Charter Duration:** Mean = 1.384

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of Observations</th>
<th>r</th>
<th>$r^2$</th>
<th>$\bar{Y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-59 months</td>
<td>123</td>
<td>.794</td>
<td>.631</td>
<td>1.551</td>
</tr>
<tr>
<td>60 and over</td>
<td>438</td>
<td>.519</td>
<td>.269</td>
<td>1.337</td>
</tr>
<tr>
<td>F = 102</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The means are **different** at 99% confidence level.

5. **Lows by Years:** Mean = 1.121

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of Observations</th>
<th>r</th>
<th>$r^2$</th>
<th>$\bar{Y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-53</td>
<td>37</td>
<td>.815</td>
<td>.664</td>
<td>1.055</td>
</tr>
<tr>
<td>1954-57</td>
<td>250</td>
<td>.684</td>
<td>.464</td>
<td>1.130</td>
</tr>
<tr>
<td>F = 59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The means are **different** at 99% confidence level.

6. **Highs by Years:** Mean = 1.387

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of Observations</th>
<th>r</th>
<th>$r^2$</th>
<th>$\bar{Y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-53</td>
<td>173</td>
<td>.751</td>
<td>.564</td>
<td>1.290</td>
</tr>
<tr>
<td>1954-57</td>
<td>391</td>
<td>.666</td>
<td>.444</td>
<td>1.430</td>
</tr>
<tr>
<td>F = 85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The means are **different** at 99% confidence level.
The above operations do not apply to vessels of over 30,000 DWT., because vessels of the latter sizes are rarely found in tie-up for reasons previously explained. Thus, for these vessels the economies of scale are reflected in the negative correlation.

(2) The relationship between short-term and long-term rates was found to be positive under both "lows" and "highs." Table 30 shows, however, a very slight negative relationship under low rates for vessels of 30,000 DWT. and over. 1 The reasons given under (1) above may also operate here, but the results may also indicate that when rates are low and the smaller vessels are led to tie-up, the remaining vessels may benefit from the consequent improvement in rates. When conditions improve, however, and the vessels in tie-up are reactivated, the resulting competition forces concession of all the economies of scale to the charterers.

(3) The coefficient of zero-order correlation between charter duration and long-term rates under "lows" for charters of less than five years' duration is positive, while the respective coefficient for charters of over five years is negative. In our theoretical discussion we concluded that the relationship would be positive, but that the slope of the normal long-term rate might reverse this relationship. Evidently (a) the negative slope of the schedule is pronounced and (b) the asymptote (normal long-term rate) is approached rather quickly (in a period of less than five years).

(4) Further evidence of 3 (b) above is provided by the relationships between the short-term and the long-term rates. The zero-order correlation coefficients and the regression equation coefficients point out that under

---

1 This correlation coefficient is not significant, but the difference between .339 and -.065 is.
TABLE 30

Selected Coefficients of Zero Order Correlation

Sub-Samples

<table>
<thead>
<tr>
<th>Sub-Samples</th>
<th>Lows</th>
<th>Highs</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Size below 29,999 DWT.</td>
<td>( r_{1y} = .339 )</td>
<td>( r_{1y} = .225 )</td>
</tr>
<tr>
<td></td>
<td>( r_{4y} = .183 )</td>
<td>( r_{4y} = -.206 )</td>
</tr>
<tr>
<td>(b) Size 30,000 DWT. and over</td>
<td>( r_{1y} = -.065 )</td>
<td>( r_{1y} = .355 )</td>
</tr>
<tr>
<td></td>
<td>( r_{4y} = -.325 )</td>
<td>( r_{4y} = .640 )</td>
</tr>
<tr>
<td>(c) Charter Duration below 59 Months</td>
<td>( r_{1y} = .235 )</td>
<td>( r_{1y} = .425 )</td>
</tr>
<tr>
<td></td>
<td>( r_{2y} = .082 )</td>
<td>( r_{2y} = -.055 )</td>
</tr>
<tr>
<td>(d) Charter Duration over 60 Months</td>
<td>( r_{1y} = .119 )</td>
<td>( r_{1y} = .100 )</td>
</tr>
<tr>
<td></td>
<td>( r_{2y} = -.110 )</td>
<td>( r_{2y} = -.090 )</td>
</tr>
</tbody>
</table>
both "highs" and "lows" the adjustment is exponential and that it is wider and more pronounced during periods of high rates. Under both cases, however, the evidence substantiates our belief that beyond a period the imaginative anticipation can penetrate, it is the cost-based normal long-term rate that serves as a guidepost.
Chapter XI

The Long-Term Rates in the Long Run

In the previous chapters, we have analyzed in detail all the factors that affect the long-term rates, but we have considered them only from the short-run point of view. Now we turn to discussion of the changes that will occur with the removal of the static assumptions.

Our previous conclusions on the relationship between the long-term rates and all the factors affecting it may be summarized as follows:

\[ R_L = R'_s - a - b + d/n (R'_s - C) \]

Where:

- \( R_L \) = The long-term rate.
- \( R'_s \) = The normal short-term rate, which under certainty would also guarantee the necessary return on investment to keep (perpetuate) fixed capital in the industry.
- \( a \) = The risk premium that the spot market commands because of the fears of unemployment.
- \( b \) = The "trouble premium" and all the "objective savings," due to administrative costs, brokerage, and mortgagability of the charter, that accrue with long-term contracts.
- \( d \) = A factor of proportionality
- \( n \) = The duration of charter.
- \( R'_s \) = The maximum average short-term rate expected to govern over period \( n \)
- \( C \) = The full cost to the industry, including the minimum necessary return on fixed capital.
Factors "a" and "b" are functions \( f(n) \) and \( g(n) \), respectively, and they will approach a limit as "n" approaches its maximum value. As for \( d/n \) \((R - C)\), it represents the impact of expectations, which, as we found, is greater the higher the spot rates \( R_s \) and the shorter the duration of the charter n. As n approaches its maximum value, the whole factor becomes insignificant, showing that the longer the duration of the contract, the greater the dependence on objective data.

If we now go from the long-term rate in the short run to the long-term rate in the long run, we find that both \( R_s' \) and C will change, whereas all the rest will remain more or less unaffected. This is so because the changes in \( R_s' \) and C are caused by changes in the long-run costs of the industry.

In the tankship service markets, as previously explained, technological economies of scale still exist, and in this chapter we shall estimate their significance, since these are so influential on long-term rates.

From our beta coefficients \( \hat{\beta}_{y4.1235...9} \) for highs and lows, and the respective standard deviations, we find that under "lows" for every 1,000 DWT. change in size, the long-term rate changes by - .054 dollars, and under "highs" by - .0144 dollars. The difference in the respective figures may be due, in the absence of errors, to:

1. The bargaining power of the two parties, which results in a smaller concession of the economies of scale on the upswing than the downswing, and

2. More pronounced economies of scale at the early stages of size.

We must not, however, depend only on our regression coefficients for this estimate because:
1. We feel that the **quantitative** exactness of regression models is not always reliable.

2. Our regression equations represent linear approximations of non-linear relationships.

3. Even if we do get a reliable quantitative indicator from a linear regression model, it will still not reflect the total impact of the economies of scale, because, as we have just mentioned, the portion of the "savings" of size conceded will be sometimes greater than others, depending on the bargaining position of the contracting parties.¹

Before we proceed with an analysis of the cost of operation, we must mention that the traditional operations of the time charter markets cause one of the factors contributing to the economies of scale to assume a different role. Because the costs of fuel, with port charges and canal tolls, are paid by the charterer under a time charter agreement, we expect to find that the more efficient vessels (because of fuel consumption) will reduce the visible impact of scale on the cost of the transportation under conditions of both surpluses and shortages.²

Unlike the spot market in which the rate is given in homogeneous units (a certain monetary consideration **per ton of oil delivered**), in the time-charter market there is no one rate, but **rates** for vessels of different sizes, ¹

---

¹Even in the absence of stringent institutional constraints, the rates for vessels of different sizes would be equalized in the market in such a way as to allow part of the economies of scale to the buyers. The latter must be compensated for the inflexibility--storage capacities, refining capacity, limitations of market size, etc.-- that the large vessel imparts.

²The cost of fuel per DWT. per year falls from about $15.20 for a T-2 to $11.23 for a 100,000 DWT. vessel, both considered in the Persian Gulf/UK trade (Cape route both ways for the 100,000 DWT. vessel).
for different lead times, and charter durations. Under such circumstances, it is impossible to establish a representative time charter rate for the total market. Most of the indices and graphs that purport to represent a market rate for time charters are misleading.\(^1\) If, of course, one can find many transactions of the same duration and involving vessels of the same size, then an index can be developed to show the rate movement in that particular submarket. As we have indicated in previous chapters, however, the number of time-charter transactions seems to be a function of rates, thus implying that there are periods during which very few or no transactions occur. Consequently, it is impossible for anyone to establish an average rate which is at the same time meaningful.

Knowing that: (a) the T-2 has been the most common vessel during the last decade, and (b) about 50% of all the time charters were for five years' duration, we have developed an index for a five-year time charter for T-2s. The results are shown in Table 31 and substantiate our reservations concerning the use of such indices. We notice that in 1954 there were no five-year time charters given to T-2s, in 1958 there was only one, in 1953 there were three, and in 1950 four, while in 1955 there were thirty-eight. The average long-term rate seems to be moving in the same direction as the short-term rate and, as expected, exhibits far narrower fluctuations than the short-term rate index. Aside from these observations, however, we cannot conclude anything on the basis of single transactions.

Just as we cannot substantiate either on theoretical or empirical grounds the use of a single long-term rate in the short-run, neither can we do so in

---

\(^1\) These graphs and indices are usually developed by tanker brokers. The London Award which depicted the cost of a two-year time charter has given way to AFRA, but the latter is not a time-charter index.
the long run. Consequently, the most logical approach toward establishing a
time-charter rate in the long run, is that of a particular cost analysis and
projections based on it.

Table 32 presents what we call the "time charter cost of operation" of
vessels from 16,500 to 100,000 DWT. The total cost per DWT. per year varies
from a high of $39.60 ($3.30 per DWT. per month) for a T-2 to $20.17 ($1.68
per month) for a 100,000 ton vessel. In terms of voyage charter equivalents,
the rate drops from ATRS minus 20% to ATRS minus 59 1/2%.

The economies of scale realized by operators of large vessels are actually
more pronounced than what is indicated by Table 32. This is so because of
two reasons:

(a) A DWT. of capacity of a large vessel is greater in terms of
actual carrying capacity than a DWT. of a small vessel, because the
speed of larger vessels is normally greater. For example, while the
speed of a T-2 (16,500 DWT.) is 14.5 knots some larger vessels
travel at 16.5 knots per hour.

(b) The fuel consumption per DWT. of capacity decreases as the size
increases. For example a 19,500 DWT. motor-driven vessel normally
consumes 28 tons of heavy fuel oil and 1 1/2 tons of diesel oil per
day of steaming, while a 86,000 DWT. motor vessel consumes only
58 tons of heavy fuel oil and 2 tons of diesel oil per day.

If we look at the two general components of the cost of Table 32, we
find that the greatest reduction in costs occurs because of the crew
requirements. As shown in Figure 35, the economies of scale due to the
shipbuilding costs taper off much faster than the crew costs.

To find the voyage rate equivalent, one has to find the time duration
of the trip (round-trip distance), multiply by the time charter rate per
day, add fuel, port charges, and canal tolls, and divide by the amount of
cargo carried, thus arriving at a rate per ton of oil delivered, instead
of rate per DWT. per month or day.
Table 31
FIVE YEARS' TIME CHARTER RATES FOR T-2s

<table>
<thead>
<tr>
<th>Date</th>
<th>No. of Transactions</th>
<th>Average Rate</th>
<th>Spot Rate Index</th>
</tr>
</thead>
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<tr>
<td>1950</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>1</td>
<td>$2.70</td>
<td>.91</td>
</tr>
<tr>
<td>November</td>
<td>3</td>
<td>3.05</td>
<td>2.82</td>
</tr>
<tr>
<td>1951</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>1</td>
<td>3.25</td>
<td>3.96</td>
</tr>
<tr>
<td>February</td>
<td>2</td>
<td>3.55</td>
<td>4.25</td>
</tr>
<tr>
<td>March</td>
<td>1</td>
<td>3.20</td>
<td>3.98</td>
</tr>
<tr>
<td>May</td>
<td>1</td>
<td>3.90</td>
<td>1.85</td>
</tr>
<tr>
<td>June</td>
<td>1</td>
<td>3.70</td>
<td>2.10</td>
</tr>
<tr>
<td>September</td>
<td>1</td>
<td>3.00</td>
<td>2.23</td>
</tr>
<tr>
<td>November</td>
<td>1</td>
<td>3.50</td>
<td>3.70</td>
</tr>
<tr>
<td>1952</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>3</td>
<td>4.35</td>
<td>4.30</td>
</tr>
<tr>
<td>February</td>
<td>2</td>
<td>3.85</td>
<td>4.24</td>
</tr>
<tr>
<td>March</td>
<td>2</td>
<td>4.00</td>
<td>4.01</td>
</tr>
<tr>
<td>May</td>
<td>1</td>
<td>4.00</td>
<td>1.72</td>
</tr>
<tr>
<td>September</td>
<td>1</td>
<td>4.10</td>
<td>1.69</td>
</tr>
<tr>
<td>October</td>
<td>1</td>
<td>4.55</td>
<td>1.56</td>
</tr>
<tr>
<td>1953</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>1</td>
<td>3.40</td>
<td>1.26</td>
</tr>
<tr>
<td>November</td>
<td>2</td>
<td>3.00</td>
<td>.90</td>
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<td>1954</td>
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<td></td>
</tr>
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<td>1955</td>
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</tr>
<tr>
<td>June</td>
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<td>July</td>
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<td>August</td>
<td>9</td>
<td>3.40</td>
<td>1.06</td>
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<td>8</td>
<td>3.35</td>
<td>1.08</td>
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<td>October</td>
<td>6</td>
<td>3.40</td>
<td>1.08</td>
</tr>
<tr>
<td>November</td>
<td>4</td>
<td>3.50</td>
<td>2.17</td>
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<tr>
<td>Year</td>
<td>Month</td>
<td>Price1</td>
<td>Price2</td>
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<tr>
<td>1956</td>
<td>January</td>
<td>2</td>
<td>3.70</td>
</tr>
<tr>
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<td>April</td>
<td>6</td>
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<td>July</td>
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<td>4.05</td>
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<td></td>
<td>August</td>
<td>1</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>2</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>October</td>
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<td>November</td>
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<td>4.75</td>
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<tr>
<td>1957</td>
<td>January</td>
<td>1</td>
<td>4.40</td>
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<tr>
<td></td>
<td>June</td>
<td>1</td>
<td>4.45</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>1</td>
<td>4.31</td>
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<tr>
<td></td>
<td>November</td>
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<td>3.43</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>3</td>
<td>3.45</td>
</tr>
<tr>
<td>1958</td>
<td>June</td>
<td>1</td>
<td>3.10</td>
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Source of Data: Columns (1) and (2), Conrad Boe Brokers, Oslo, Norway
Column (3), same as Table 12
<table>
<thead>
<tr>
<th>Size DWT.</th>
<th>16,500</th>
<th>20,000</th>
<th>30,000</th>
<th>40,000</th>
<th>50,000</th>
<th>60,000</th>
<th>70,000</th>
<th>80,000</th>
<th>90,000</th>
<th>100,000</th>
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<tbody>
<tr>
<td><strong>Cost Per Annum</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Wages, Provision, Insur. etc.</td>
<td>213,694</td>
<td>223,450</td>
<td>234,350</td>
<td>250,700</td>
<td>261,600</td>
<td>277,950</td>
<td>288,850</td>
<td>299,750</td>
<td>316,100</td>
<td>327,000</td>
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<tr>
<td>Repairs &amp; Maintenance</td>
<td>110,000</td>
<td>120,960</td>
<td>147,850</td>
<td>173,600</td>
<td>201,600</td>
<td>228,480</td>
<td>255,360</td>
<td>282,240</td>
<td>308,000</td>
<td>336,000</td>
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<tr>
<td>Vessel Insurance</td>
<td>45,690</td>
<td>56,060</td>
<td>77,710</td>
<td>98,160</td>
<td>116,690</td>
<td>135,460</td>
<td>153,790</td>
<td>172,130</td>
<td>192,270</td>
<td>212,120</td>
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<td>Overhead</td>
<td>21,900</td>
<td>22,000</td>
<td>22,000</td>
<td>22,000</td>
<td>22,000</td>
<td>22,000</td>
<td>22,000</td>
<td>22,000</td>
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<tr>
<td><strong>Per DWT./Annum</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$391,284</td>
<td>422,470</td>
<td>481,900</td>
<td>544,460</td>
<td>601,890</td>
<td>663,890</td>
<td>720,000</td>
<td>776,120</td>
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<td><strong>Depreciation &amp; Interest on</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fixed Investment 8%</td>
<td>253,440</td>
<td>296,000</td>
<td>410,400</td>
<td>518,400</td>
<td>616,000</td>
<td>715,200</td>
<td>812,000</td>
<td>908,800</td>
<td>1,015,200</td>
<td>1,120,000</td>
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<tr>
<td><strong>Per DWT./Annum</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.36</td>
<td>14.80</td>
<td>13.68</td>
<td>12.96</td>
<td>12.32</td>
<td>11.92</td>
<td>11.60</td>
<td>11.36</td>
<td>11.28</td>
<td>11.20</td>
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<tr>
<td>Total Cost Per DWT./Annum</td>
<td>39.60</td>
<td>35.92</td>
<td>29.74</td>
<td>26.57</td>
<td>24.36</td>
<td>22.98</td>
<td>21.89</td>
<td>21.06</td>
<td>20.60</td>
<td>20.17</td>
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<td><strong>Voyage Charter Equivalent</strong></td>
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</tr>
<tr>
<td>A.T.R.S.</td>
<td>-20%</td>
<td>-27 1/2%</td>
<td>-40%</td>
<td>-46 1/2%</td>
<td>-51%</td>
<td>-53 1/2%</td>
<td>-56%</td>
<td>-57 1/2%</td>
<td>-58 1/2%</td>
<td>-59 1/2%</td>
</tr>
<tr>
<td><strong>General Information</strong></td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Crew</td>
<td>40</td>
<td>41</td>
<td>44</td>
<td>46</td>
<td>48</td>
<td>50</td>
<td>53</td>
<td>55</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td>Construction Cost/DWT.</td>
<td>$192</td>
<td>185</td>
<td>171</td>
<td>162</td>
<td>154</td>
<td>149</td>
<td>145</td>
<td>142</td>
<td>141</td>
<td>140</td>
</tr>
<tr>
<td>Total Cost in $M</td>
<td>3,168</td>
<td>3,700</td>
<td>5,130</td>
<td>6,480</td>
<td>7,700</td>
<td>8,940</td>
<td>10,150</td>
<td>11,360</td>
<td>12,690</td>
<td>14,000</td>
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<tr>
<td>Repair Cost in $M</td>
<td>100</td>
<td>108</td>
<td>132</td>
<td>156</td>
<td>180</td>
<td>205</td>
<td>230</td>
<td>254</td>
<td>277</td>
<td>300</td>
</tr>
</tbody>
</table>

With such a great range of costs, there remains no doubt that the long-term market consists of many components that could easily qualify as separate markets. This subdivision, of course, introduces imperfections in the long-term markets, and we can no longer talk about rate equalization as in the spot market. In the case of the long-term rates the question arises: equalization to what? All this provides further evidence that only cost can serve as a guide-post in the long-term markets, as we have been claiming for several other reasons all the way along. Let us mention again, however, that this adherence to a cost-based rate does not imply that the owner retains no part of the economies of scale. Part of the latter must stay with the owner to compensate him for the greater risks (costlier unemployment, and more limited use); another part must go to the charterer to compensate him for the inflexibility introduced into his operations; and the incidence of the remaining part will be determined by the prevailing market forces. It is only in this way that rate equalization can be understood in the long-term markets.

Our regression model has shown that for every 1,000 DWT. change in size, the long-term rate changes by $-.054 during periods of low rates and $-.0144 during periods of excess demand. We will now test and see how this compares with objective economic data.

Because the mean size of vessels chartered under low rates is 17,912 and the standard deviation 7,413, we shall assume a critical (two tails) value of 5% and see how the cost behaves when size increases from, let us say, 16,500 to 30,000 (actually it should be 17,912±14,826 but there are no vessels at the lower end). From Table 32 we notice that the total cost
falls from $3.30 per DWT. per month to $2.48, a drop of $.82 per DWT. per month. According to the regression model, the rate changes by -.054 times 13.5 or $.73, which is a very good approximation of $.82. Furthermore, since we observed a tendency for a positive relation during low rates for small sizes, we must actually test at the upper end of the spectrum. Thus we find that the difference in cost between 20,000 DWT. and 30,000 DWT. is 51 cents according to Table 32, while our model predicts 54 cents. Under high rates, on the other hand, the mean is 22,255 and the standard deviation 19,439; this, we will test between 20 and 60 thousand DWT. vessels. The cost per DWT. per month at 20,000 is approximately $3.00 and at 60,000 DWT. is $1.92, showing a difference of $1.08 per DWT. per month. The regression model gives us -.0144 times 40 or only 58 cents. The difference between 30,000 and 60,000 DWT. vessels is given as 56 cents per DWT. per month by Table 32 and 43 cents by the model.

The difference between cost and predicted rate under high rates may be due to any one or a mixture of the following reasons:

(a) The assumptions of linearity in our model.

(b) The impact of wide spot-rate fluctuations which will tend to shift the time-charter rate upward.

(c) To the bargaining power of the negotiating parties, which will determine the deviations from long-run costs (after the risks on both sides are considered). Under periods of excess demand, the wide fluctuations of the spot rate and the charterers' expectations develop a market climate favorable to the owners. With elastic expectations, then, it is only natural for the charterers to concede to the owners a greater part of the economies accruing to size under high rates than under low rates. It is the charterer who is under pressure during periods of excess demand and the owner during periods of excess supply.
The question of what will happen to the long-term rates in the long run is still with us. On the basis of the results shown in Table 32, there is no doubt that the trend will be downward as the composition of the fleet slowly changes. The level in an AFRA rate in the future will definitely be decreasing. However, such changes in the average level of long-term rates are not expected to be more than gradual.

Fluctuations around this downward average normal long-term rate are to be anticipated in the average market long-term rate because of expectations and the relationship that exists between the short-term and the long-term rates; but again these are short-run considerations and have no more than a transient impact on the long-run level of the long-term rates.
Chapter XII

A Brief Summary

In Chapter I of this study, we suggested that traditional static analysis does not explain rate formation in the tankship markets. We have indicated that any price movement away from the theoretical equilibrium point will create expectations about future rates. These expectations will then cause interperiod substitutions which will affect the demand schedules of both ship chartering and shipbuilding.

The impact of expectations on the demand schedules is immediate, but it will not be reflected in the available tankship capacity until sometime later because of the construction lead time. Given this difference in the timing of the impacts of rate expectations on supply and demand, we concluded that short-term rates are formed by the interaction of the demand schedule as affected by expectations and the static supply schedule. The empirical shape of these two schedules was consequently given extensive treatment.

Chapter II was devoted to a theoretical discussion of the influence of expectations on the stability of equilibria. The traditional as well as current theories on this subject were discussed and proved to be based on symmetry of expectations between buyers and sellers, and uniformity of the schedules of expectations. According to existing theory, elasticities of expectations greater than unity cause market instability, because prices will be either increasing or falling continuously.
Having extended the use of the fundamental theory of value to the case of producer goods and interperiod profit maximization, we applied the Slutsky-Hicks formulation and analyzed the impact of a present price change on interperiod substitutions. We found that even under the traditional assumptions of symmetry in the behavior of buyers and sellers, price-elastic expectations do not necessarily create perpetually explosive price patterns. The price movements are bounded and one-way stable equilibria can occur outside the region of strict static relevance. Alternatives to the traditional hypothesis were then suggested some of which assume (a) asymmetry of behavior between buyers and sellers, (b) regular but non-uniform schedules of expectations, (c) alternating patterns in expectations, (d) "zero" memory for buyers and/or sellers and (e) immediate or delayed reaction on the part of the sellers. In each case a relative stability is guaranteed in markets which are affected by expectations of elasticity greater than one, and where the applicable demand schedules have slopes that alternate between positive and negative values.

Chapter III dealt with the shape of the demand schedule for tankship capacity. Considerable discussion was devoted to the relationship between the demand for oil and that of tankship tonnage in order to establish the theoretical shape of the static demand schedule. The latter was found to be virtually of infinite inelasticity, and we, therefore, attributed the difference between infinite inelasticity and the elasticity of the empirical demand schedule to interperiod substitutions, caused by expectations.

The shape of the empirical demand schedules was the subject matter of Chapter IV. The empirical approximations to what we have called demand schedules revealed the impact of elastic expectations. This implies that
once an initial disturbance occurs, which Chapter V guarantees, the necessary mechanism for cyclical tanker rates is established. The initial change in rates will generate expectations about future price changes and will thus cause interperiod substitutions. The latter, if we assume fixed supply, will cause further price increases which in turn will affect expectations, and so on. In addition to movements along a demand schedule with positive slope (outside the region of strict static relevance), consecutive shifts in the demand schedule may also occur, further aggravating price movements and interperiod substitutions. This spiral will continue until either expectations change from elastic to inelastic (for reasons exogenous to rates), the buyers withdraw from the market because of the negative budget effect or the supply schedules shift and reverse the movement in rates. Once such a reversal occurs prices will plummet. The drop in prices will automatically turn the "speculative" purchases into surpluses. The latter will be especially pronounced if elastic expectations still operate, because such expectations will dictate reverse interperiod substitutions. Prices will then remain at very low levels until the next disturbance occurs to repeat the cycle. It is for these reasons that a cyclical demand is not necessary to the mechanism of cyclical prices.

Chapter V presented a detailed analysis of the factors affecting the supply schedule of tankship services. New orders placed and tie-ups were proved to be the most important factors affecting the supply schedule. Our theoretical formulations showed that the changes in orders placed are governed mainly by two interperiod substitution effects and two static income effects. The two substitution effects are the result of expectations generated by spot rates and shipbuilding costs, respectively, and they are
positive or negative depending on the price elasticities of expectations in the tankship service and tankship building markets. The two income effects oppose each other, but the net result is expected to be positive, as long as spot rates increase, because of the greater price fluctuations in the tankship service market.

Other factors affecting orders are replacements and the pattern of ownership of existing capacity. On the basis of available evidence, the big oil companies order vessels during periods of surplus capacity in the hope of reducing their dependence on chartered vessels.

A considerable discussion was devoted to the differences between the expectations and behavior of the oil companies and independents. We have shown analytically that the manifested behavior of the independents is consistent with either price-elastic or inelastic expectations, as long as the oil companies have elastic expectations. The conditions under which the independents will order vessels if their expectations were inelastic were then fully analyzed.

The empirical evidence supports our contention that expectations in the tankship-building market are elastic. This observation applies to both the oil companies and independents, although the coefficient of expectations is greater in the case of the oil companies and their reaction pattern lags that of the independents. Vessels are ordered mainly when rates are high and do not appear in the market until after rates have dropped. As a result, depressions are prolonged and the preconditions for cyclical replacements (and shortages) are established.
Vessels scrapped were found to be independent of the conditions that generate orders for new vessels. In fact spot rates and vessels scrapped are negatively correlated, implying that normal replacements do not affect orders in any significant way.

The economics of slow-downs, repairs and tie-ups were extensively discussed. Although important savings can be realized if the speed of vessels is varied depending on spot rates, yet very little evidence exists that tanker operators take advantage of such practices. Repairs and tie-ups were found to be related, because operators find it advantageous to wait out periods of uncertainty by stretching necessary repairs. When hope is lost the vessels are led to tie-up.

The empirical schedule of tie-ups is almost "L" shaped, betraying infinite inelasticity in the short-term supply schedule above practical full capacity, and infinite elasticity below.

The factors that affect the short-term supply schedule are discussed in Chapter VI. It is shown that the short-term supply schedule is infinitely inelastic beyond full capacity and extremely elastic below. The capacity that separates the elastic from the inelastic part of the short-term supply schedule is not greater than 2% of the total, and the range of rates within which such transformation occurs is approximately 40 cents per 1,000 ton-miles, out of a total range of approximately $4.00.

The tanker markets paradoxically operate in a fashion resembling perfect competition. The various reasons behind this paradox were analyzed in Chapter VII. It was pointed out that institutional considerations in the final markets for oil, and imbalances between the production and refining capacities as well as between geographical regions for the various oil
companies necessitate an independent tanker market. Self-sufficiency for oil companies would imply perpetual instability and chronic surpluses. The aforementioned factors plus: the mobility of capital which reduces the cost of exit from any particular market and serves toward global equalization of supply and demand; the easy of entry caused by exceptional methods of financing and risk elimination; the absence of large administrative and financial optima which permit the vessel to operate as a firm; and the absence of excessive artificial national and international controls, all contribute toward the perfectly competitive climate of the tankship markets.

Chapter VIII deals with the formation of short-term rates. It shows that the shape of the demand schedule in the region affected by interperiod substitutions will cause violent fluctuations in the spot rates above the static long-run equilibrium point. Because of the extreme inelasticity of the supply schedule in this region, the fluctuations will be swift and extensive. Rates will remain at high levels until expectations, short-selling, or new capacity precipitates a downturn, and then they will slide continuously until they reach the tie-up cost of the marginal capacity. There, rates will remain fluctuating below the static long-run equilibrium until either shifts in demand or attrition eliminate the excess capacity and create shortages. When this takes place, spot rates will be forced above the full cost of the marginal vessel, influence expectations, shifts in demand, etc., and will start another cycle.

The adjustment paths followed by spot rates are similar to those of the classical cobweb theorem. We have found, however, that there are many cobwebs within cobwebs (i.e., cobwebs of different durations occurring
simultaneously) in the tankship markets. These fluctuations have as central focus the static long-run equilibrium, but they are not expected to reach and remain at such an equilibrium, because it is unstable. Consequently, spot rates are fluctuating either temperately below the static long-run equilibrium point or violently above.

Chapter IX analyzes the factors that influence long-term charter rates in the short run. The analysis suggests that the long-term and the short-term rates will move in the same direction and that the long-term rates will not exhibit the volatility of the spot rates. There will be real differences (not for fuel, etc.) between the levels of the two rates, however, because of: (a) the uncertainties and expectations over the period covered by the long-term contract, (b) the unemployment risks inherent in the operations of the spot market, (c) the subjective value of certainty, (d) the administrative savings made possible by the long-term contracts, (e) the loan value of the long-term charters and (f) the expected savings due to improvements in technology over the tenure of the time charter.

As the duration of the charter lengthens, the long-term rates are expected to approach the normal long-term rate from above during periods of high rates, and from below during depressed market conditions. Because of the negative slope of the normal long-term rate, the long-term charter rates during periods of excess demand may show signs of bending backward as the duration of the contract lengthens.

The theoretical formulations explaining the formation of the long-term rates in the short run were subjected to multiple regression and correlation analysis, and the results proved very satisfactory. The model and the analyses to which it was subjected are found in Chapter X.
Finally, Chapter XI suggests that because of the heterogeneity among vessels and the absence of a representative number of transactions, it is impossible to draw any conclusions concerning the long-term rate in the long run. On the basis of our analysis included in Chapters IX and X, which suggests that the normal long-term rate is based on cost, we draw the conclusion that the level of long-term rates (in general) will be moving downward, reflecting the economies of scale that tankship transportation is still realizing.
Appendices

I. Definition of Technical Terms

II. Method for Conversion of Time-Charter Rates into Spot Rate Equivalent

III. Coding Instructions for Data Used
   A. Charters
   B. Tie-Ups
   C. New Orders
   D. Spot Rates
   E. Gulf Oil Company Charter Data: 24,000 DWT. and Below

IV. Coded Data
   A. Charters, Conrad Boe Ltd., Data: All Sizes
   B. Tie-Ups
   C. New Orders
   D. Spot Rates
   E. Gulf Oil Company Charter Data: 24,000 DWT. and Below

V. Sources of Data Used in Figures

VI. Bibliography
Appendix I

Definition of Technical Terms

AFRA
The Average Freight Rate Assessment (AFRA) is supposed to show the average cost of a ton of oil delivered. Thus it is not a current index but a mixture of current and historic costs intended to show at any moment of time the cost of oil being in transit.

A. T. R. S.
This term stands for the American Tanker Rate Schedule. It is an index aimed at substituting U.S.M.C. The latter is found unsatisfactory because it covers large areas under the same rate and also because it includes the canal tolls as a part of the basic rate.

Bareboat Charter
This type of agreement provides for the delivery of a "bare" vessel to the charterer. The latter assumes responsibility for providing crew, provisions, supplies, fuel and whatever else is needed.

Charter
As used in the tankship markets a charter is a contract.

Clean
Clean refers to cargoes of gasoline and other refined products.

Consecutive Voyage Charter
Similar to single voyage but for either an extended number of "consecutive" trips or extended time period.

Contract of Affreightment
An agreement providing for the transportation of a given amount of oil between two ports over an extended period of time but on such vessels and at such times as the owners find advantageous. A provision in the agreement may define "minmax" limits of monthly flows. These contracts, which are not very common, are not consummated for speculative reasons. Their purpose is to alleviate frictional unemployment and utilize ballasted capacity.

Dirty
This term refers to crude oil cargoes.

Fixture
A contract for a vessel, same as a charter.
Newbuilding
A new vessel under construction, on order, or to be ordered.

Relet
A relet is a sublet vessel.

Scale
This is the English equivalent to the A.T.R.S. Since its inception there have been three revisions so the latest is Scale No. 3.

Scrapping
Breaking up old vessels for scrap metal.

Single Voyage (Spot) Charter
An agreement for a single voyage between two ports. The payment is made on the basis of tons of oil delivered. The owner of the vessel is responsible for all expenses.

Tie-Up or Lay-Up
This term refers to idleness for economic reasons. When a vessel is in tie-up it is under the care of only a skeleton crew that stands watch and performs minor repairs.

Time Charter
A contract of longer duration than a single voyage. The rent (hire) is paid usually on the basis of deadweight tons per month, and it does not include fuel for propulsion, port charges, or canal tolls.

T-2 Equivalent
In the absence of size homogeneity, the industry is using the T-2 as a measure of capacity. To convert into T-2 equivalents, one has to multiply the deadweight by the speed of a vessel and divide by 16,500 x 14.5. It must be noted that the T-2 equivalent is only a rough measure of capacity.

T-2
For the purposes of this study, we only need to know that a T-2 is a tanker of approximately 16,500 deadweight tons, achieving speeds of 14.5 to 14.6 knots.

U.S.M.C.
As used in this study, U.S.M.C. stands for the index of rates formulated in 1947 by the United States Maritime Commission for the major runs. Specific rates are expressed in terms of plus or minus percentages of the "flat" (100%) U.S.M.C. rate.

Working Petroleum Fleet
The working petroleum fleet is equal to the total fleet less government-owned (commercial) vessels, special purpose ships, and vessels idle either because of tie-ups or repairs of over 30 days.
Appendix II

Method for Conversion of Time-Charter Rates into Spot Rate Equivalent

Suppose that we observe the following transaction:

"A vessel of 65,000 DWT., fitted with a steam turbine and capable of traveling at 16 knots per hour on 111 tons of Bunker "C" fuel oil per day, receives a 5-year time charter at $1.73 per DWT. per month."

We now wish to find the spot rate equivalent of the above transaction, in other words the cost per ton of oil delivered. Under a time-charter agreement, the charterer pays for bunkers, canal tolls, and port charges, which are all paid by the owners in the case of a spot charter. Furthermore, the charterer pays a flat rate per unit of potential gross carrying capacity (DWT.) per month in the case of a time charter, while on a spot basis be pays for actual tons of oil delivered. As a result we must choose a run, translate the tonnage of a vessel into potential tons of oil delivered, and then derive the cost per ton of oil.

Assuming that the vessel is to be used in the Caragao/London/Caragao run, the mechanics of such translation, using the information given above as a basis, are as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Distance in miles (roundtrip)</td>
<td>8,440</td>
</tr>
<tr>
<td>2.</td>
<td>Distance traveled per day ((24 \times 16)) in miles</td>
<td>384</td>
</tr>
<tr>
<td>3.</td>
<td>Days steaming per round trip ((1)/(2))</td>
<td>22.0</td>
</tr>
<tr>
<td>4.</td>
<td>Days in port for loading and unloading including delays</td>
<td>3.50</td>
</tr>
<tr>
<td>5.</td>
<td>Total days for completing a trip</td>
<td>25.50</td>
</tr>
</tbody>
</table>
6. Trips per year (maintenance is "off hire")  14.314

7. Carrying capacity per trip

(a) DWT. of capacity  65,000
(b) Less: Water and Stores (300)
(c) Less: Bunkers assuming all are purchased at loading point
   (i) For steaming 111 x 22 = (2,442)
   (ii) Safety 111 x 5 = (555)
   (iii) Port 18 x 3.5 = (63)  62,740

8. Carrying capacity per year in tons  898,000

9. Total Cost:

(a) Fuel: 35,856 x $13/ton = $466,128
(b) Port Charges, loading ports 14.314 x $1,204 = 17,234
(c) Port Charges, port of discharge 14.314 x $7,294 = 104,406
(d) Charter hire: 1.73 x 65,000 x 12 = 1,349,400
(e) Commission 1 1/2% of charter hire* 20,241 $1,957,409

10. Cost per ton of oil delivered approximately $2.18

11. Flat (100%) Scale per ton delivered $4.55

12. Spot rate equivalent of time charter

Scale = \[
\left\lceil 100 - \frac{(10)}{(11)} \right\rceil
\]
Scale Minus 52.1%

*We assume that the charterer pays the commission.
### Appendix III

#### Coding Instructions

**A. Charters**

<table>
<thead>
<tr>
<th>Name of Field</th>
<th>Columns From - To</th>
<th>No. of Columns</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Code of Ship</td>
<td>1-4</td>
<td>4</td>
<td>Pick Code from List</td>
</tr>
<tr>
<td>II Relet or Not</td>
<td>5</td>
<td>1</td>
<td>Use 0 for NonRelet; Use 1 for Relet</td>
</tr>
<tr>
<td>III Date of Fixture</td>
<td>6-11</td>
<td>6</td>
<td>Use only 2 Last Digits of Year</td>
</tr>
<tr>
<td>IV Months to Delivery</td>
<td>12-13</td>
<td>2</td>
<td>See Detailed Instructions</td>
</tr>
<tr>
<td>V Type of Fixture</td>
<td>14</td>
<td>1</td>
<td>See Detailed Instructions</td>
</tr>
<tr>
<td>VI Duration of Fixture</td>
<td>15-17</td>
<td>3</td>
<td>See Detailed Instructions</td>
</tr>
<tr>
<td>VII Tons of Cargo</td>
<td>18-23</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>VIII Type of Cargo</td>
<td>24</td>
<td>1</td>
<td>0 for Dirty; 2 for Option both D and C; 1 for Clean; 3 for Other; 4 50%L 50% D.</td>
</tr>
<tr>
<td>IX Run: From</td>
<td>25</td>
<td>1</td>
<td>See Detail</td>
</tr>
<tr>
<td>X Run: To</td>
<td>26-27</td>
<td>2</td>
<td>See Detail</td>
</tr>
<tr>
<td>XI Rate (Type)</td>
<td>28</td>
<td>1</td>
<td>See Detail</td>
</tr>
<tr>
<td>XII Amount in Terms of Index</td>
<td>29-34</td>
<td>6</td>
<td>See Detail</td>
</tr>
<tr>
<td>XIII Amount in Terms of $ or £</td>
<td>35-39</td>
<td>5</td>
<td>See Detail</td>
</tr>
<tr>
<td>XIV Followed by Type of Fixture</td>
<td>40</td>
<td>1</td>
<td>See Detail</td>
</tr>
<tr>
<td>XV Preceded by Type of Fixture</td>
<td>41</td>
<td>1</td>
<td>See Detail</td>
</tr>
<tr>
<td>XVI Charterer</td>
<td>42-43</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>XVII Whether Part Cargo</td>
<td>44</td>
<td>1</td>
<td>If Part Cargo Use 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>If Full Cargo Use 0</td>
</tr>
<tr>
<td>XVIII Delivery Option</td>
<td>45</td>
<td>1</td>
<td>If yes use 1</td>
</tr>
<tr>
<td>XIX Conrad Boe Data Time-Charters</td>
<td>80</td>
<td>1</td>
<td>Punch 1</td>
</tr>
<tr>
<td>Gulf Oil Company Data Time Charters</td>
<td></td>
<td></td>
<td>Punch 9</td>
</tr>
</tbody>
</table>
Instructions

IV. Months to Delivery: Convert into months
   If prompt use 0
   If within one month use 1
   If within two months use 2
   and so on
   If more than 99 months use 99

V. Type of Fixture
   Firm commitment:
   0 Single voyage
   1 Consecutive voyages in number
   2 Consecutive voyages in months
   3 Trading (Time Charter) in months (if in years convert to months)
   4 Bareboat Charter in months (if in years convert to months)
   Option:
   5 Option for consecutive in number
   6 Option for consecutive in months
   7 Option for trading (time charter) in months
   8 Contract of affreightment (in M tons per year)
      See more on this under XI - XV.
   9 Option single voyage

VI. Duration of Fixture
   Duration of above V in number or months where applicable. For
   single voyage you need nothing.

VII. Tons of cargo as given. Except in contracts of affreightment, the
cargo is in thousand tons per year.

Detail

IX. Run: From
   0 U. S. Gulf
   1 Caribbean Sea, Venezuela
   2 Persian Gulf, Ras Tanura, Bahrein
   3 USNH
   4 Sidon, Tripoli, Banias, Lebanon, Eastern Mediterranean
   5 California, San Francisco, San Pedro
   6 Sumatra, Singapore, East Indies
   7 World Wide
   8 Black Sea
   9 Other
X. Run: To
0 U. S. N. H. (New York)
1 Philadelphia and South East Coast
2 California
3 Canada and N. S.
4 Cartagena, Teneriffe
5 South America
6 U. K. and non-specified (other) continent
7 Scandinavia
8 Netherlands, Belgium, and Germany
9 France
10 Italy
11 Other Mediterranean (North and South)
12 Other Africa (excluding North Africa)
13 Australasia
14 India, Pakistan and Ceylon
15 Far East (excluding Japan)
16 Japan
17 World Wide
18 U. S. Gulf
19 Other
20 Caribbean
21 East Mediterranean
22 Antarctic round voyage
23 Western Hemisphere
24 Central America

XI. Rate (Type)
No punch Cost Plus
0 U. S. M. C.
1 Scale
2 M. O. T.
3 Dollars in Lump Sum (in hundreds)
4 Sterlings in Lump Sum (in hundreds)
5 Dollars "per ton" (use always 2 decimal figures)
6 X/-Shillings "per ton" (use always 2 decimal figures)
   27/6 as 27.50
   27/11 as 27.92
7 London Brokers' Assessment--this is expressed in terms of Scale
8 Min. Max. in Scale
9 Min. Max. in terms of U. S. M. C. Notice this is very, very rare. Unless it specifies U. S. M. C., it is AFRA in Scale

XII Amount in Terms of Index
A. Convert everything to a straight % of base. Use 2 decimal places.
   For example:
   Scale plus (+) 60% convert to 16000
   U. S. M. C. minus (-) 60% convert to 4000
   Same for M. O. T.
B. Use 2 decimal figures for classifications 0, 1, 2, 5, and 6 above. (See XI, Rate, above.)

C. For "Lump Sum" leave out the two last digits. Namely, record sums in hundreds. No decimals here.

D. For classifications 8 and 9 of XI, use always 3 figures for min. (minimum) and 3 figures for max. (maximum). No decimals here. E.g., min. max. 50/85. Record 150185.
min. max. -15/10. Record 085090.
If a decimal exists, round it.

XIII Amounts in Terms of Dollars or Shillings
Wherever a rate is given in both index form and rate in dollars or sterlings, record here the latter. Use always 2 decimal points.
If the rate is given in both dollars and pounds and also U. S. M. C. and Scale (U. S. M. C. is dollars and Scale is pounds), use U. S. M. C. and dollars.
If dollars or shillings are given, use 2 decimal points.
E.g., 27/ = 2700
27/6 = 2750 or $10.02 = 1002
27/11 = 2792 or 8.73 = 0873

XIV and XV Followed by Type of Fixture and Preceded by Type of Fixture
Whenever a fixture is being followed by another fixture or an option for a fixture, make a notation in column 40 of the first card as to what type of fixture follows (see V) and make a new card for the following fixture. For each new card in column 41 put the type of preceding fixture.
Each new card will have all the details as the original.
If a time charter or consecutive voyage is fixed for 5/7 years or 20/22 voyages, make a card for the first amount, i.e., 5 years or 20 voyages and consider the other (2 years or 2 voyages) as option.
<table>
<thead>
<tr>
<th>Charterer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Not Known</td>
<td>17 M. S. T. S.</td>
</tr>
<tr>
<td>1 Anglo American</td>
<td>18 Other (All Other)</td>
</tr>
<tr>
<td>2 Anglo Iranian</td>
<td>19 Paragon</td>
</tr>
<tr>
<td>3 Atlantic Refining</td>
<td>20 Petrofina</td>
</tr>
<tr>
<td>4 British Petroleum (B. P.)</td>
<td>21 Shell</td>
</tr>
<tr>
<td>5 British Tanker Company</td>
<td>22 Sinclair</td>
</tr>
<tr>
<td>6 California Oil</td>
<td>23 Socony Vacuum (Sovac)</td>
</tr>
<tr>
<td>7 Caltex</td>
<td>24 Soponata</td>
</tr>
<tr>
<td>8 C. F. R.</td>
<td>25 Stanic</td>
</tr>
<tr>
<td>9 Cities Service</td>
<td>26 Standard Vacuum (Stanvac)</td>
</tr>
<tr>
<td>10 Eagle Oil (and Shipping)</td>
<td>27 Sun Oil</td>
</tr>
<tr>
<td>11 Escomberas</td>
<td>28 Texas</td>
</tr>
<tr>
<td>12 Esso</td>
<td>29 Tidewater</td>
</tr>
<tr>
<td>13 Gulf</td>
<td>30 Union Oil</td>
</tr>
<tr>
<td>14 Hess</td>
<td>31 Shared by two or more</td>
</tr>
<tr>
<td>15 A. Johnson</td>
<td></td>
</tr>
<tr>
<td>16 Mitsubishi</td>
<td></td>
</tr>
</tbody>
</table>
### B. Tie-Ups (in terms of T-2's)

<table>
<thead>
<tr>
<th>Name of Field</th>
<th>Columns</th>
<th>No. of the Columns</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Date.</td>
<td>6</td>
<td>1-6</td>
<td>Two columns for the month, day and year (e.g., January 1, 1948-010148).</td>
</tr>
<tr>
<td>II. Real Tie-Ups (beginning of month).</td>
<td>4</td>
<td>7-10</td>
<td>One decimal place (e.g., 34.2, 138.2)</td>
</tr>
<tr>
<td>III. Real Tie-Ups plus idle (beginning of month).</td>
<td>4</td>
<td>11-14</td>
<td>One decimal.</td>
</tr>
<tr>
<td>IV. Working Petroleum Fleet.</td>
<td>5</td>
<td>15-19</td>
<td>One decimal.</td>
</tr>
<tr>
<td>V. Real Tie-Ups as percent of working Petroleum Fleet.</td>
<td>3</td>
<td>20-22</td>
<td>One decimal.</td>
</tr>
<tr>
<td>VI. Real Tie-Ups plus idle as percent of Working Petroleum Fleet.</td>
<td>3</td>
<td>23-25</td>
<td>One decimal.</td>
</tr>
<tr>
<td>VII. Item V above in period t as a percent of the same item in period t-1.</td>
<td>3</td>
<td>26-28</td>
<td>No decimal. (\frac{V_t}{V_{t-1}} \times 100)</td>
</tr>
<tr>
<td>VIII. Item VI above in period t as a percent of the same item in period t-1.</td>
<td>3</td>
<td>29-31</td>
<td>No decimal. (\frac{VI_t}{VI_{t-1}} \times 100)</td>
</tr>
<tr>
<td>IX. Identification</td>
<td>1</td>
<td>80</td>
<td>Punch 3 in Column 80.</td>
</tr>
</tbody>
</table>
### C. New Orders (monthly)

<table>
<thead>
<tr>
<th>Name of Field</th>
<th>Columns</th>
<th>No. of the Columns</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Date.</td>
<td>6</td>
<td>1-6</td>
<td>Two columns for the month, day and year.</td>
</tr>
<tr>
<td>II. Orders outstanding (beginning of month).</td>
<td>5</td>
<td>7-11</td>
<td>One decimal place.</td>
</tr>
<tr>
<td>III. Working Petroleum Fleet.</td>
<td>5</td>
<td>12-16</td>
<td>One decimal.</td>
</tr>
<tr>
<td>IV. Orders outstanding as percent of Working Petroleum Fleet.</td>
<td>3</td>
<td>17-19</td>
<td>No decimal.</td>
</tr>
<tr>
<td>V. Item IV above in period (t) as a percent of the same item in period (t-1).</td>
<td>3</td>
<td>20-22</td>
<td>No decimal. ((\text{IV}<em>t/\text{IV}</em>{t-1} \times 100))</td>
</tr>
<tr>
<td>VI. Index of new orders placed (during the month).</td>
<td>5</td>
<td>23-27</td>
<td>One decimal. Index of new orders placed = 1000.0 + new orders placed (during the month).</td>
</tr>
<tr>
<td>VII. Item VI above in period (t) as a percent of item II in period (t-1).</td>
<td>3</td>
<td>28-30</td>
<td>No decimal. ((\text{VI}<em>t/\text{II}</em>{t-1} \times 100))</td>
</tr>
<tr>
<td>VIII. Item VII above in period (t) as a percent of the same item in period (t-1).</td>
<td>3</td>
<td>31-33</td>
<td>No decimal. ((\text{VII}<em>t/\text{VII}</em>{t-1} \times 100))</td>
</tr>
<tr>
<td>IX. Index of new orders placed as a percent of Working Petroleum Fleet.</td>
<td>3</td>
<td>34-36</td>
<td>No decimal. ((\text{VI}_t/\text{III}_t \times 100.))</td>
</tr>
<tr>
<td>X. Item IX above in period (t) as a percent of same item in period (t-1).</td>
<td>3</td>
<td>37-39</td>
<td>No decimal. ((\text{IX}<em>t/\text{IX}</em>{t-1} \times 100.))</td>
</tr>
<tr>
<td>XI. Identification.</td>
<td>1</td>
<td>80</td>
<td>Punch 4 in Column 80.</td>
</tr>
</tbody>
</table>
### D. Spot Rates (monthly)

<table>
<thead>
<tr>
<th>Name of Field</th>
<th>Columns</th>
<th>No. of the Columns</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Date.</td>
<td>6</td>
<td>1-6</td>
<td>Two columns for the month, day, and year.</td>
</tr>
<tr>
<td>II. Averate Rate Index per 1,000 miles ($a_t$).</td>
<td>3</td>
<td>7-9</td>
<td>Two decimal places.</td>
</tr>
<tr>
<td>III. Expectation Index (EI).</td>
<td>3</td>
<td>10-12</td>
<td>No decimal. $EI = .53 \frac{a_t}{a_{t-1}} + .27 \frac{a_{t-1}}{a_{t-2}} + .14 \frac{a_{t-2}}{a_{t-3}} + .06 \frac{a_{t-3}}{a_{t-4}}$ where $a_t = $ average rate index per 1,000 miles.</td>
</tr>
<tr>
<td>V. Averate Rate (including tolls) for Persian Gulf/U. K.</td>
<td>4</td>
<td>13-16</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>V. Averate Rate (excluding tolls)* for Persian Gulf/U. K. per 1,000 miles.</td>
<td>3</td>
<td>17-19</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>VI. Average Rate (including tolls) for Persian Gulf/U. S.</td>
<td>4</td>
<td>20-23</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>VII. Average Rate (excluding tolls)** for Persian Gulf/U. S. per 1,000 miles.</td>
<td>3</td>
<td>24-26</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>VIII. Average rate for Caribbean/ U. K.</td>
<td>4</td>
<td>27-30</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>IX. Average Rate for Caribbean/ U. K. per 1,000 miles.</td>
<td>3</td>
<td>31-33</td>
<td>One decimal.</td>
</tr>
<tr>
<td>X. Average Rate for Caribbean/ U. S.</td>
<td>4</td>
<td>34-37</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>XI. Average Rate for Caribbean/ U. S. per 1,000 miles.</td>
<td>3</td>
<td>38-40</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>XII. Average Rate for U. S. Gulf/ N. H.</td>
<td>4</td>
<td>41-44</td>
<td>Two decimals.</td>
</tr>
<tr>
<td>XIII. Average Rate for U. S. Gulf/ N. H. per 1,000 miles.</td>
<td>3</td>
<td>45-47</td>
<td>Two decimals.</td>
</tr>
</tbody>
</table>
### D. Spot Rates (monthly) continued

<table>
<thead>
<tr>
<th>Name of Field</th>
<th>Columns</th>
<th>No. of the Column</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>XIV. Average Rate Index converted to USMC equivalent based on Aruba/NY run.</td>
<td>4</td>
<td>48-51</td>
<td>One decimal. Take Average Rate Index per 1,000 miles (See II. above) and multiply by distance from Aruba to New York (1750) and divide by 1,000. Then convert to USMC rate.</td>
</tr>
<tr>
<td>XV. Average Rate Index converted to Scale #2 equivalent based on Aruba/NY run.</td>
<td>4</td>
<td>52-55</td>
<td>One decimal. Same as above except convert to Scale #2.</td>
</tr>
<tr>
<td>XVI. Identification.</td>
<td>1</td>
<td>80</td>
<td>Punch 5 in Column 80.</td>
</tr>
</tbody>
</table>

*13¢ subtracted

**10¢ subtracted
Notes on the punched cards for

(1) New Orders
(2) Spot Rates
(3) Tie-Ups

(1) If data are missing the number of columns called for by the FORMAT is left blank (i.e., the space key is used instead of the skip key -- no hole is punched in the card).

(2) Decimals are omitted (e.g., 1266.9 would appear on card as 12669).

(3) If the data occupy less than the number of columns called for by the FORMAT then the vacant columns are filled with zeros (e.g., if five columns are "called for" and the datum is 4173 then it would be punched as 04173).

(4) The number in columns 25-27 for December 1951 in the Tie-Ups cards should be infinity. It was made 100 as computer cannot handle infinity.
E. Gulf Oil Company Charter Data

Format for Multiple Correlation Card

<table>
<thead>
<tr>
<th>Name</th>
<th>Columns No. of Fm: To: Columns</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>1 - 4</td>
<td>4</td>
</tr>
<tr>
<td>Date of Fixture</td>
<td>5 -10</td>
<td>6</td>
</tr>
<tr>
<td>Long term rate (dependent variable)</td>
<td>11 -13</td>
<td>3</td>
</tr>
<tr>
<td>Lead time</td>
<td>14 -15</td>
<td>2</td>
</tr>
<tr>
<td>Duration of charter</td>
<td>16 -18</td>
<td>3</td>
</tr>
<tr>
<td>Size (tons of cargo)</td>
<td>19 -23</td>
<td>5</td>
</tr>
<tr>
<td>Short term rate index (spot)</td>
<td>24 -26</td>
<td>3</td>
</tr>
<tr>
<td>Index of expectation</td>
<td>27 -29</td>
<td>3</td>
</tr>
<tr>
<td>New Orders (Item IV)</td>
<td>30 -32</td>
<td>3</td>
</tr>
<tr>
<td>New Orders (Item VIII)</td>
<td>33 -35</td>
<td>3</td>
</tr>
<tr>
<td>Tie-Ups (Item VIII)</td>
<td>36 -38</td>
<td>3</td>
</tr>
<tr>
<td>Tie-Ups (Item VI)</td>
<td>39 -41</td>
<td>3</td>
</tr>
<tr>
<td>$(X_{4t}/X_{4t-1}) \times 100$</td>
<td>42 -44</td>
<td>3</td>
</tr>
<tr>
<td>$(X_{5t}/X_{5t-1}) \times 100$</td>
<td>45 -47</td>
<td>3</td>
</tr>
<tr>
<td>Identification</td>
<td>80</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: The Gulf Oil Company collected charter data for vessels of 24,000 D.W.T. and below only. We used these data to check on the comparable relationships derived by using Conrad Boe data. No significant differences were observed although each had transactions not recorded by the other.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>No. of Columns</th>
<th>Location of Column</th>
<th>Decimals</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent (y)</td>
<td></td>
<td>3</td>
<td>11-13</td>
<td>2</td>
<td>From Deck 1, Columns 35-39. If Column 28 is 5, proceed; if 6 convert to dollars.</td>
</tr>
<tr>
<td>Independent (X₁)</td>
<td>b₁</td>
<td>2</td>
<td>14-15</td>
<td>0</td>
<td>From Deck 1, Columns 12-13</td>
</tr>
<tr>
<td>Independent X₂</td>
<td>b₂</td>
<td>3</td>
<td>16-18</td>
<td>0</td>
<td>From Deck 1, Columns 15-17</td>
</tr>
<tr>
<td>Independent X₃</td>
<td>b₃</td>
<td>5</td>
<td>19-23</td>
<td>0</td>
<td>From Deck 1, Columns 18-23</td>
</tr>
<tr>
<td>Independent X₄</td>
<td>b₄</td>
<td>3</td>
<td>24-26</td>
<td>2</td>
<td>From Deck 5, Columns 7-9</td>
</tr>
<tr>
<td>Independent X₅</td>
<td>b₅</td>
<td>3</td>
<td>27-29</td>
<td>0</td>
<td>From Deck 5, Columns 10-12</td>
</tr>
<tr>
<td>Independent X₆</td>
<td>b₆</td>
<td>3</td>
<td>30-32</td>
<td>0</td>
<td>From Deck 4, Columns 17-19</td>
</tr>
<tr>
<td>Independent X₇</td>
<td>b₇</td>
<td>3</td>
<td>33-35</td>
<td>0</td>
<td>From Deck 4, Columns 31-33</td>
</tr>
<tr>
<td>Independent X₈</td>
<td>b₈</td>
<td>3</td>
<td>36-38</td>
<td>0</td>
<td>From Deck 3, Columns 29-31</td>
</tr>
<tr>
<td>Independent X₉</td>
<td>b₉</td>
<td>3</td>
<td>39-41</td>
<td>1</td>
<td>From Deck 3, Columns 23-25</td>
</tr>
<tr>
<td>Independent X₁₀</td>
<td>b₁₀</td>
<td>3</td>
<td>42-44</td>
<td>1</td>
<td>From Deck 9, Columns 42-44</td>
</tr>
<tr>
<td>Independent X₁₁</td>
<td>b₁₁</td>
<td>3</td>
<td>45-47</td>
<td>1</td>
<td>From Deck 9, Columns 45-47</td>
</tr>
</tbody>
</table>

*If not all spaces are needed, zeros are used.*
Appendix V

Sources of Data Used in Figures

Figures 1-5: Theoretical


Figures 9-13: Rates: same as in Figure 6.
New Orders Placed: Transportation Co-ordination Department, Standard Oil Company (New Jersey).

Figure 14: Cost of Vessels: Fairplay Index (see Fairplay semi-annual issues).

Figures 15-29: Rates: Same as in Figure 6.

Figures 30-32: Deliveries, Orders Outstanding, Size of Fleet, Number, Age and Size of Vessels Scrapped, Repairs, Idle Fleet and Tie-Ups: Transportation Co-ordination Department, Standard Oil Company (New Jersey).

Figures 33-34: Charters: Conrad Boe Ltd., Shipbrokers, Oslo; R. S. Platou A/S, Shipbrokers, Oslo. For method of conversion of time charter rates to spot rate equivalent see Appendix II.

Figure 35: Cost of Operation: Marine Brokerage, New York.
Data and bibliography to be completed later.
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