AN ECONOMETRIC MODEL OF THE WORLD SHIPPING MARKETS

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DECLARATION

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ABSTRACT

This thesis presents an aggregated econometric model of the world shipping markets. The model distinguishes between dry cargo and tankers and also between the a) freight market, b) second hand market for ships, c) shipbuilding market, d) scrap market.

Chapters 1, 2 of the thesis examine the history of shipping in the last 100 years or so, analyse the cyclical behaviour of the industry, and consider past theoretical attempts at modelling the shipping markets. It is argued that the structure of existing models of the shipping industry is theoretically flawed in its treatment of the demand for new and second hand ships as well as in the treatment of expectations.

Chapter 3 presents a 'new' theoretical model of the behaviour of shipping markets that attempts to remedy these defects. Novel features of this theory are the assumption of 'rational expectations' in shipping markets as well as the treatment of new and second-hand ships as assets, the portfolio demand for which varies with the own expected return relative to the return on other assets.

Econometric versions of the theoretical model are estimated from post World War II annual data, separately for the dry cargo and tanker sectors in chapters 4, 5. The two models are linked in chapter 6 and the models are used in order to simulate the dynamic response of the shipping markets to anticipated and unanticipated external shocks. A crucial role in the adjustment process is played by the forward looking speculative positions of investors in the second hand and newbuilding markets.

Chapter 7 tests the assumption of the rational expectations hypothesis in the shipping markets by examining the evidence from the freight futures, time charter and newbuilding markets. The stochastic behaviour of these variables is examined and statistical tests are performed in order to investigate the extent to which this is considered to be consistent with the efficient markets / rational expectations hypothesis. The results are somewhat mixed.

Chapter 8 illustrates how the model can be used for real world forecasting purposes and scenario planning.

SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS

CGRT	Compensated Gross Registered Tons
DWT	Deadweight Tons
EMH	Efficient Market Hypothesis
FIML	Full Information Maximum Likelihood
IV	Instrumental variables
LDT	Light Deadweight Tons
OLS	Ordinary Least Squares
RE	Rational Expectations
TCE	Time Charter Rate Equivalent
2SLS	Two stage Least Squares
3SLS	Three Stage Least Squares
$E_{t+j}X_{t+k}$	Expectation at time t+j of X_{t+k}
ΔX_t	$X_t - X_{t-1}$
FX_t	X_{t+1}
F^kX_t	X_{t+k}
LX_t	X_{t-1}
L^kX_t	X_{t-k}

SYMBOLS

A	Proportion of ships in age group
AS	Average Size
CP	Shipbuilding Capacity
D	Deliveries of new ships
F	Freight rate
f	Futures Price
H	Time Charter Rate
K	Fleet size
Kv	Trading Fleet
L	Ship Losses
LC	Costs in Lay-up
LH	Length of Haul
n	Spot Price
OC	Operating Costs

P	Second-hand Ship Price
P_1	Shipbuilding Cost
P_b	Unit Voyage Cost Index
p_d	Proportion of Combis in dry
P_n	Newbuilding Price
p_o	Proportion of Combis in oil
P_s	Price of Scrap
Q	Orders for newbuildings
q	Demand for ton-miles
r	Return on capital
S	Scrappings
s	Scrapping rate
V	Present Value of Time Charter
W	World Wealth
x	Freight Market Balance
Y	World Economic Activity
Z	Scrapping Capacity
λ	lay-up (%)
π	Profit
$\tilde{\pi}$	Time Charter Equivalent
σ	Speed

INTRODUCTION AND OVERVIEW

This thesis attempts to model the way equilibrium freight rates, second-hand and newbuilding prices, shipbuilding output and scrapping are determined by the interactions and exogenous impulses affecting the freight market, second-hand, newbuilding and scrapping market.

Chapter 1 examines the history of freight rates, prices, shipbuilding and scrapping over the last 100 years or so. It relates the fluctuations in these variables to the influence of external factors. It draws on an extensive database in order to discuss the characteristic features of a typical shipping cycle.

Chapter 2 reviews previous attempts at modelling the behaviour of shipping markets. It is argued that past attempts have been deficient in two important respects. First, new and second-hand ships have not been treated as capital assets. Secondly, expectations have not been treated properly.

Chapter 3 develops a theoretical model which aims to remedy these deficiencies in past work. Thus both newbuilding and second hand ships are treated as capital assets. Secondly, expectations are assumed to be rational. This allows us to simulate the market's response to anticipated or unanticipated shocks.

In chapter 4, 5 the theory is used in order to specify and subsequently estimate an econometric model of the dry cargo and tanker market respectively. These models are also used in order to carry out simulations of the effects of various shocks.

In chapter 6 the individual dry cargo and tanker models are linked into an integrated model of the shipping markets. This integration allows us to simulate the spillover effects from one sector to the other. These spillover effects reflect the freight, shipbuilding and scrap market links that exist between the two sectors.

Chapter 7 tests the assumption of rational expectations in the various shipping markets. Evidence from freight futures, time charter and newbuilding markets is used. Unbiasedness, weak rationality and semi-strong rationality tests are performed.

Chapter 8 illustrates how the model can be used for forecasting and scenario planning and presents forecasts of the shipping industry up to the year 2000. The implications of a Base Run scenario are analysed as well as those of alternative scenarios involving anticipated and unanticipated oil shocks.

The main results of this study are the following: Firstly, the theoretical analysis illustrates the role of speculation and the importance of 'news'. The overshooting behaviour of rates, prices, shipbuilding and scrapping during a hypothetical cycle is demonstrated. The actual cyclical patterns are consistent with rational behaviour in an enviroment characterised by uncertainty.

Secondly, the empirical estimates for the freight market sector are consistent with a priori views and with the results of other studies. The empirical results for the ship markets are also consistent with a priori expectations and give support to the capital asset approach. Simulations of the empirical models allow us to derive sensitivity results regarding the response of the market to various shocks. The spillover effects from the tanker to the dry cargo sector and vice versa are weak. The rationality tests indicate that the assumption of rational expectations in the time charter market cannot be rejected while the results for the freight futures markets are somewhat mixed.

Finally, the forecasts indicate that the recent recovery in freight rates and prices is largely sustainable and is expected to be followed by a doubling of shipbuilding output and a permanent reduction in scrappings.

CHAPTER 1

A HUNDRED YEARS OF WORLD SHIPPING

This chapter presents the history of world shipping in the last 100 years. The presentation heavily relies on the use of charts. The main movements in the external factors such as the growth of trade, fuel and metal prices and interest rates are considered and their effect on the shipping markets is analysed.

The introductory section briefly discusses the interrelationship bewtween world trade and shipping. Section 2 considers the history of the dry cargo market in the last 100 years. Three separate periods are distinguished; pre-World War I, the interwar period and the post war period. Section 3 does the same for the tanker market. The post war period is also divided into a pre and post OPEC era.

Section 4 takes another look at the historical evidence and identifies the characteristic patterns of a typical shipping cycle. A main objective of this thesis is to explain why and how these patterns arise.

1.1 Introduction

Ever since 1500 BC, sail ships are known to have carried cargoes across the Mediterranean Sea. The alternative of overland transportation was at the time much more dangerous, time consuming, costly and sometimes not even feasible. The invention of the ship significantly reduced the costs of trade and opened up new possibilities. There followed an expansion in trade, enabling the world as a whole to enrich itself by leading to a general increase in output through specialization in production according to comparative advantage. The surplus output of individual areas could then be exchanged for the produce of other parts of the world, increasing the availability of goods at home.

Trade and shipping have always been inextricably interwoven. On the one hand, ships provide cheap transportation services thereby reducing the economic barriers to trade. On the other hand it is the desire to trade that generates the demand for shipping. Shipping would not exist but for trade. In turn the primary causes of trade are the individual local demand and supply conditions for various goods in various parts of the world. In the absence of trade these would determine the local prices of goods. These in general would differ across various countries. When trade becomes feasible there is an enormous economic incentive to carry goods from areas where they are cheap to areas where they can be sold for a higher price, thereby generating a demand for transportation services.

The existence of the shipping industry also presupposes a shipbuilding industry capable of supplying the market with new vessels at a sufficiently low cost. Low shipbuilding costs are required so that the minimum freight rates needed to recover the capital invested, are low enough so as not to prohibit trade. This was crucial for the initial development of the industry. In recent years, technological advances in shipbuilding have pushed freight rates to such a low level, that they now represent a very small proportion of the price of the goods carried. Trade is therefore no longer sensitive and dependent on fluctuations in freight rates but it is purely determined by the other factors mentioned above as well as the trade policies of the participating countries.

Throughout the rest of this study, trade will be considered to be completely determined by these other factors, so that it generates a purely inelastic demand for shipping transportation services. It is outside the scope of this thesis to look further into the primary determinants of the pattern and volume of trade. The main objective will rather be to analyse both theoretically and empirically the impact of fluctuations in the level of demand for freight and of other exogenous factors such as fuel prices, shipbuilding costs, interest rates etc., on the shipping markets. Chapter 3 utilizes the suggestions of economic theory in order to model the behaviour of economic agents in the freight, second hand, shipbuilding and scrapping markets. In the subsequent chapters, we use empirical data from the 1950s up to the 1980s, in order to estimate an econometric model of the post war shipping markets, based on the theory of chapter 3. The model aims to provide an explanation for the cyclical patterns in freight rates, prices, shipbuilding and scrappings. It may also be used as a forecasting tool and for simulating how the market responds to various shocks.

This chapter takes an extensive look at the actual historical movements in the shipping markets over the last 100 years. The evidence comes in the form of long term time series and covers the more distant past as well as the postwar period. The reasons for doing this are manifold. First, in sections 1.2 and 1.3, the data are simply used in order to give a short outline of the economic history of world shipping over the last 100 years or so. The theoretical framework of chapter 3 is used in order to analyse the major cyclical episodes and secular trends and to relate them to various exogenous shocks. In passing we shall take the opportunity to use the data in order to support or question the theoretical framework. Finally, another objective of this introductory review of the data will be to pinpoint the major patterns of a typical shipping cycle. This is the main theme of section 1.4. A theoretical explanation of why and how these patterns arise is one of the main objectives of this study.

1.2 Historical fluctuations in the dry cargo market

Historical fluctuations are interesting in their own right but they are also useful for comparison with the more recent ones. These can suggest whether the various market mechanisms and the patterns they generate have been stable over long periods of time. We find that the historical cyclical episodes bare an extremely close resemblance to more recent ones which suggests that there has been a stable underlying market structure for over a century. In spite of the enormous changes in ship types, trade patterns, modes of operation, shipbuilding techniques, propulsion technology etc. that have taken place over the period under review, we still find that the aggregate fluctuations in market conditions can be explained in terms of four interacting markets being subjected to various external shocks. These markets are the above mentioned freight, second hand, shipbuilding and scrap markets and the exogenous shocks are the fluctuations in the growth rate of international trade, fuel prices, shipbuilding costs, returns to capital and other factors. Because of its nature, our historical investigation necessarily relies on quantitative data and the period of the study has been solely determined by data availability. The history is presented by means of charts which are followed by a discussion which relates the market movements shown on the charts to changes in external conditions which are also depicted on various graphs and tables.

We shall take a separate look at the dry cargo and tanker markets bearing in mind that the two have always been closely related. Market fluctuations are analysed separately for the following three distinct periods: pre-World War, which begins from round about 1870; inter War, which covers the 1920s and 1930s; and postwar which covers the more recent history from the 1950s up to the 1980s. For each period, the fluctuations in the exogenous factors such as the growth rate of demand, fuel prices, shipbuilding costs and interest rates are presented first in charts. A following set of charts then presents the oscillations in the shipping markets that were induced by fluctuations in the exogenous factors and speculation concerning their influence.

The accompanying discussion to the charts, does not limit itself to a mere factual description of events and empirical correlations. It rather aims to analyse market fluctuations more intelligently by using a theoretical framework which is explained in detail in chapter 3.

1.2.1 Theoretical Prelude

Here, we briefly summarise the theory we present in chapter 3 about how the various markets behave and interact and how they respond in the short run and in the longer term to various shocks. We hope that this will assist the reader in following the discussion of the charts. The theory distinguishes between four shipping markets; the freight, second hand, shipbuilding and scrapping markets. There are four major external factors which influence these markets. These are the volume of trade, fuel prices, shipbuilding costs and alternative returns to capital. The volume of trade directly affects the freight market by raising the demand for freight services. Bunker prices also have a direct impact on the freight market by creating an incentive for ships to slowsteam and economize on fuel costs thereby reducing the supply. Shipbuilding costs operate directly through the shipbuilding market by affecting the supply of new ships. Metal prices which are part of the shipbuilding costs additionally influence the market by affecting the demand and price of scrap. Returns to capital affect the prices investors are willing to pay for ships given their expectations of future profits.

The cyclical patterns that an external shock will generate very much depends on whether the shock is anticipated or not. Indeed genuine news relating to a future expected shock will have a peculiar and immediate effect on the market through speculation. Here, for the purposes of our historical investigation we shall give more emphasis on how the market responds to *unanticipated* shocks since, indeed, the major market fluctuations have been induced by events which were totally unexpected. For example the two world wars, the Boer and Korean wars, the trade wars of the 1930s, the closures of the Suez Canal or the oil shocks of the seventies which had a great impact on the shipping industry through changes in demand for freight, fuel and metal prices and interest rates, were completely unforeseen by the market.

Because the fleet is fixed in the short run, demand and bunker shocks will have an immediate and strong short term impact on the freight market and the markets for ships. In the long run however the market tends to absorb such shocks through compensating changes in the size of the fleet. On the other hand shipbuilding cost and interest rate shocks have a smaller short term impact which increases in the long run as the changes in the fleet brought about by the shock are accumulated. For these reasons changes in shipbuilding costs and returns to capital are not empirically very relevant for analysing cyclical fluctuations. They are rather more relevant for explaining secular trends. On the other hand demand and bunker shocks tend to induce significant cyclical movements.

An increase in demand leads to higher freight rates and insofar as this has not been anticipated, it can lead to large simultaneous increases in prices, shipbuilding output and associated reductions in scrappings. The fleet can only respond slowly so the freight market boom can last for some time. The increase in values however will raise the future fleet via reductions in scrappings and increased supply of newbuildings. This will cancel most of the short run changes in market conditions. Thus in the long run the market tends to absorb the shock and return towards the path that it would have followed in the absence of the shock.

An increase in fuel prices operates directly through the supply of transportation services in the freight market. It generates an incentive to slow steam and this leads to an increase in freight rates. Because demand is inelastic, this increase in rates outweighs the increase in costs, so profits also increase, assuming of course that demand has not changed following the change in fuel prices. Here too, if these developments are unanticipated, they will also lead to contemporaneous increases in prices and shipbuilding and reductions in scrapping. These developments are also short term, since in the long run the expansion of the fleet will cancel most of the initial changes.

Shipbuilding costs directly affect the supply of new ships at a given level of ship prices. An increase in shipbuilding costs has a negative effect on the supply of new ships. This restraint in the growth rate of the fleet, leads to an increase in future freight rates and through expectations it also raises current prices. The latter causes a reduction in scrappings and partly offsets the negative effect of the increase in costs on the supply of new ships but not completely.

Changes in alternative returns to capital operate directly through the second hand market by affecting the speculative asset demand for ships. At a given level of expected profitability, an increase in alternative returns to capital leads to a drop in ship values. This in turn reduces the supply of new ships and increases scrapping. The lower growth rate of the fleet will thus increase future freight rates and profits which will help to cushion the initial speculative drop in values without however cancelling it completely.

Unlike demand and fuel shocks, changes in shipbuilding costs and alternative returns to capital have a very small impact in the short term but a bigger effect in the long run. It is only gradually that the accumulated changes in the size of the fleet brought about by increases in shipbuilding costs and returns to capital affect the freight market balance and rates.

These are the effects of permanent unanticipated changes in the external factors on the shipping markets. The major fluctuations in market conditions over the period of our study have indeed been induced by such unanticipated shocks. As already mentioned changes in demand for freight, interest rates, fuel and metal prices during the World Wars or the trade wars of the 1930s or during the closures of the Suez Canal or after the oil shocks of the 1970s have indeed been unanticipated. The above discussion is therefore relevant for analysing their effects. However the market can move in anticipation of a change in an external factor and the cyclical patterns generated under such conditions can be quite different from those which would arise if the shock had been unforseen. Only in the case of an increase in alternative returns to capital do we get similar patterns whether the change is anticipated or not.

If the increase in demand is anticipated it will lead to speculative increases in prices and thence the fleet. Since demand has not as yet risen, rates will initially fall and only when and if the change in demand materializes will rates increase. Similar reasoning applies for an anticipated change in fuel costs. An anticipated increase in shipbuilding costs will lead to speculative increases in ship values. Since costs have not yet increased shipbuilding will initially expand and rates will drop. Only after the increase in costs occurs will the fleet begin to drop and rates to rise. The long run effects however of a shock are similar whether the shock has been anticipated or not. The effects of various external shocks are more thoroughly analysed in the theoretical discussion of chapter 3 and later on by means of computer simulations of the estimated econometric model.

1.2.2 The pre-World War I dry cargo market

Data for this period are available from as far back as 1869. This was a period of rapid structural change both for the world economy and the shipping markets as well. These, of course, were related to the process of industrialization which had a significant influence on the demand and supply side of the shipping industry. When we pick up the story, the process is already well under way. On the demand side, industrialization implied a significant increase in the growth rate of demand for freight, as the world economy expanded rapidly and together with it the volume of international transactions. The composition of demand also changed as shipments of industrial commodities such as coal and later on iron ore grew much faster than that of the traditional agricultural grain shipments. On the supply side the impact of industrialization came through the technological invention of the steamer and new shipbuilding techniques that contributed to a reduction in the cost per ton of building a ship. During our first period of study the sail ship became obsolescent as a result of the appearance of the more efficient steamer. The steamer brought about a secular decrease in freight rates which in turn led to the demise of the sail ship.

Our study of the pre-World War I period can be conceptually divided into two parts. The first part considers the aggregate cyclical fluctuations in rates, prices and the total size of the fleet brought about by changes in external factors. This part does not consider the diverging paths followed by the sail and steamer sectors during this period of time. We aggregate the fleet statistics for the two separate sectors together by using the standard 3 to 1 relationship between a steam ton and a sail ton as assumed by the English statistical publications of the time. In the second part we disaggregate, so as to analyse how within a generally growing market we have a declining sail sector and a rapidly expanding steamer one.

Aggregate Market Fluctuations

Fig. 1.1 to 1.6 show the developments in the major external factors during the period under review. Figure 1.1 shows the level and composition of demand from 1870 up to 1913. The implied growth rate of demand is plotted on Fig. 1.2. In the first 10 years, demand grew very rapidly at the extremely high rate of 7.4% p.a. on average. The world economy on the other hand did not grow faster than 2.5% p.a. Industrialization was shipping-intensive for many reasons. During that period the major industrial power was Great Britain. Being an island and an open economy it generated a big demand for shipping. Coal was the major source of energy and the growth of industry increased the demand for coal shipments.

Traditional methods of production were mainly aimed towards satisfying local demand as high land transport costs and diseconomies of scale prevented extreme local specialization in production that would have led to an increase in trade. Improvements in road and railway transport also contributed to an increase in shipments since other modes of transport are complements rather than substitutes to shipping. Together with the economies of scale that were associated with the modern production methods, reductions in land transportation costs encouraged increased specialization in production. Surplus output would be exported to other areas in exchange for imported goods that would satisfy the excess local demand.

From 1880 to 1890 the growth rate dropped to an

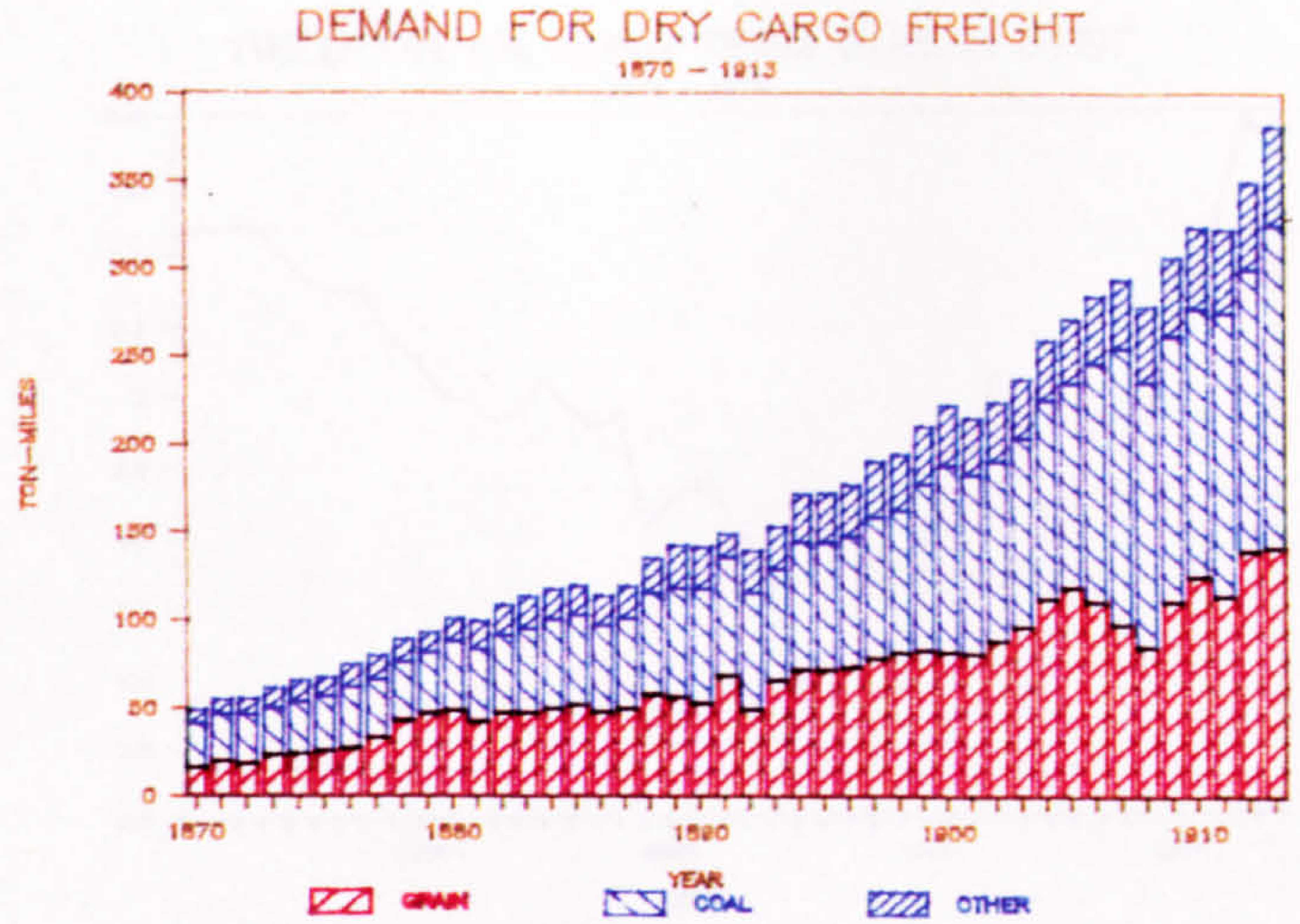


FIG. 1.1

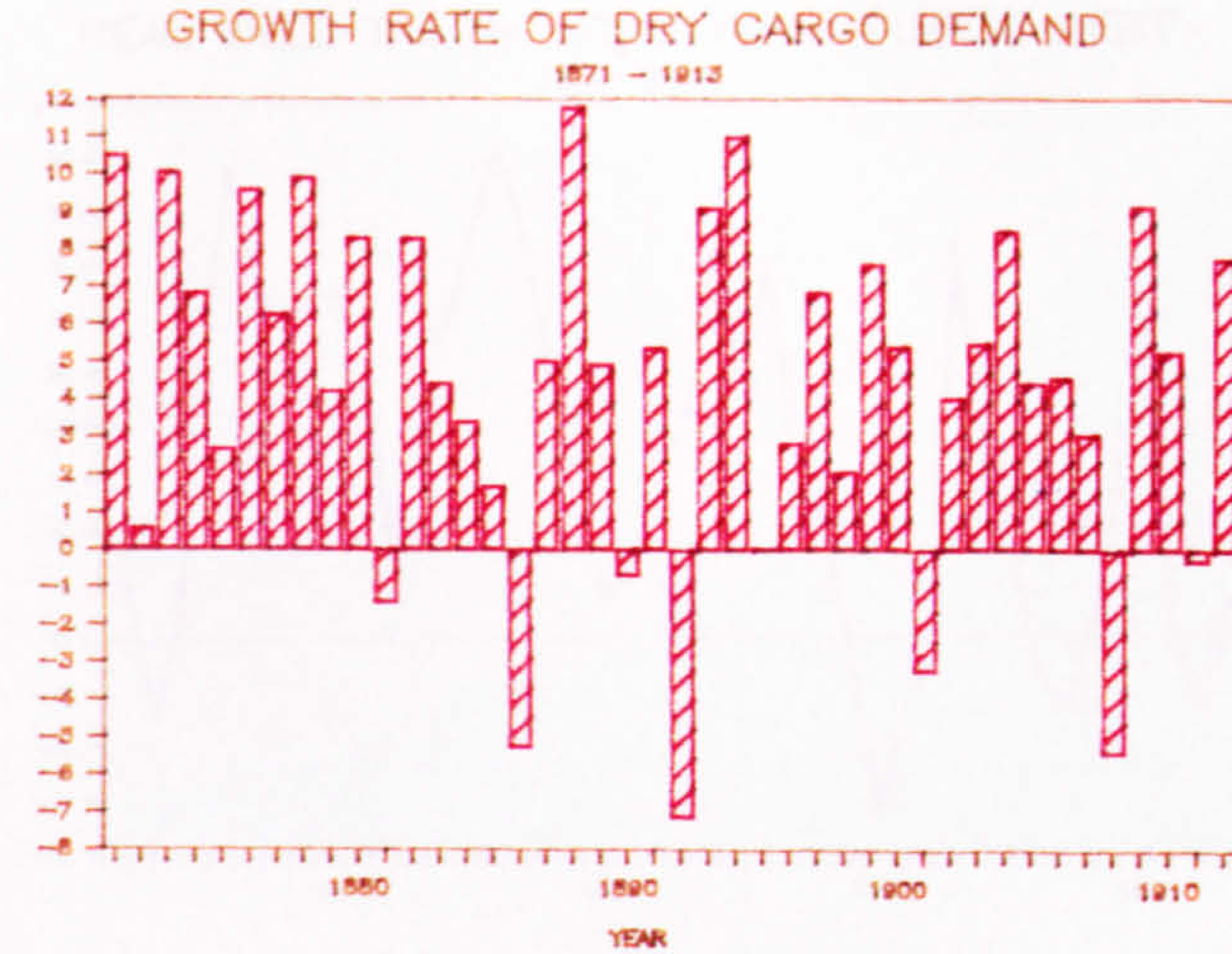


FIG. 1.2

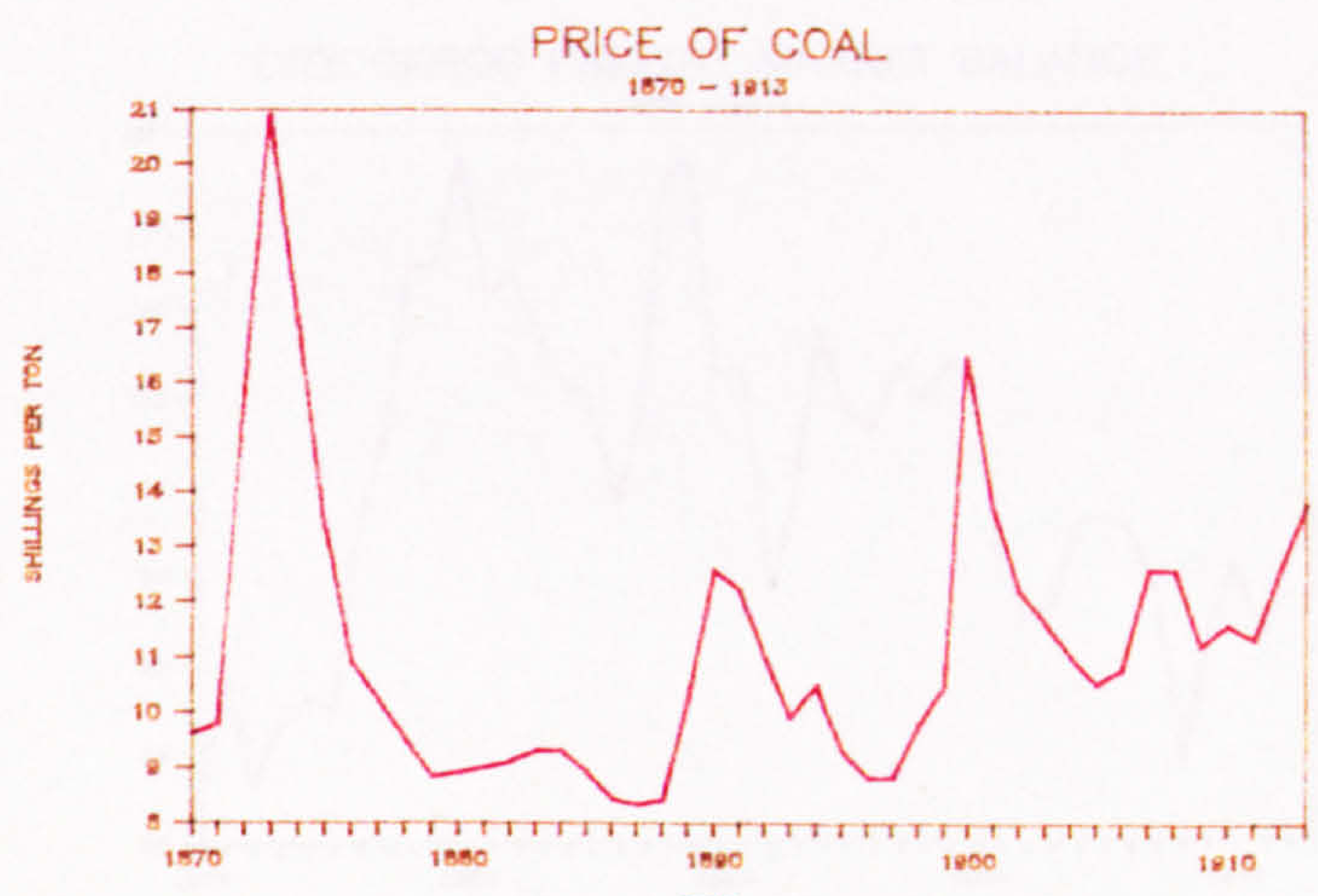


FIG. 1.3

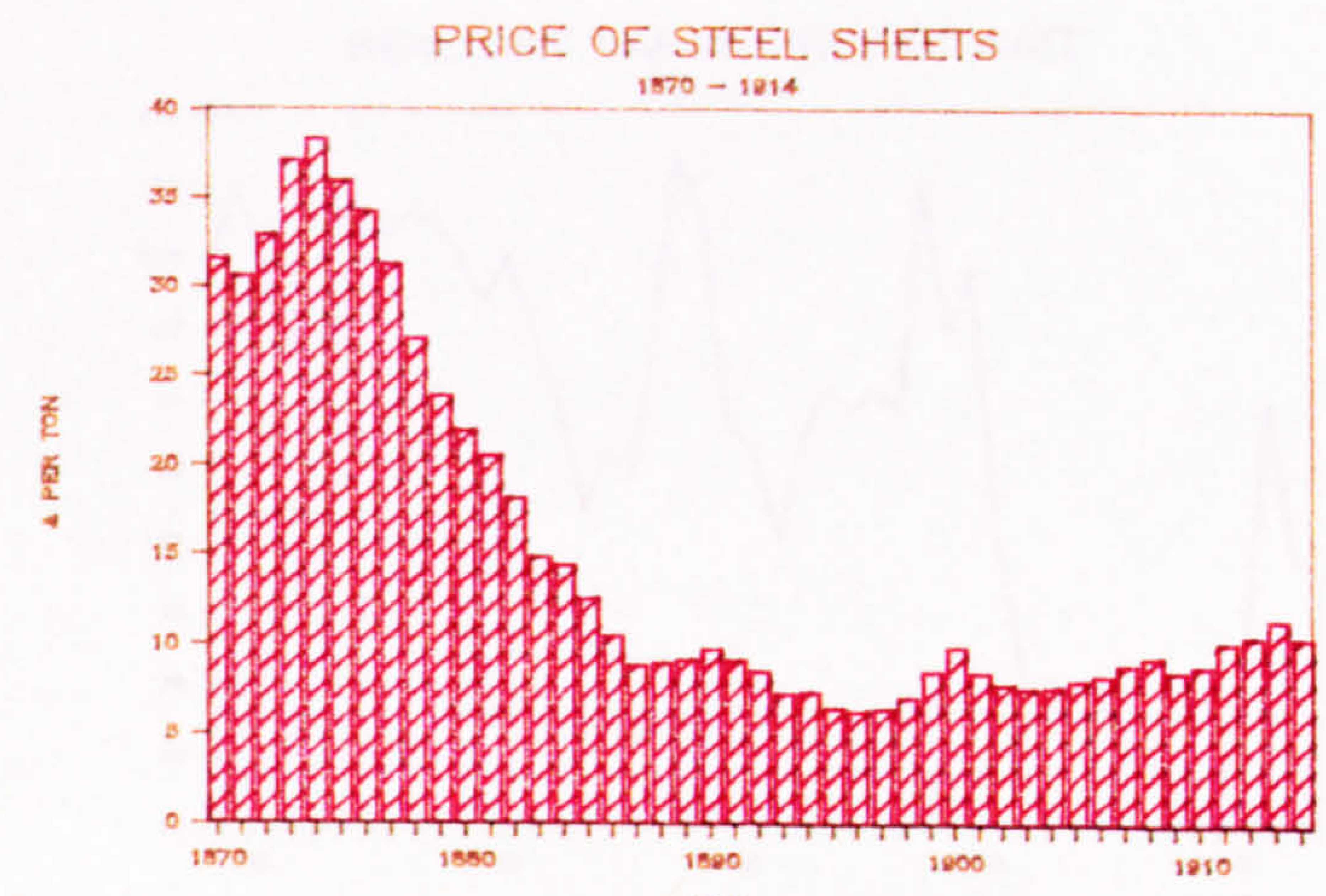
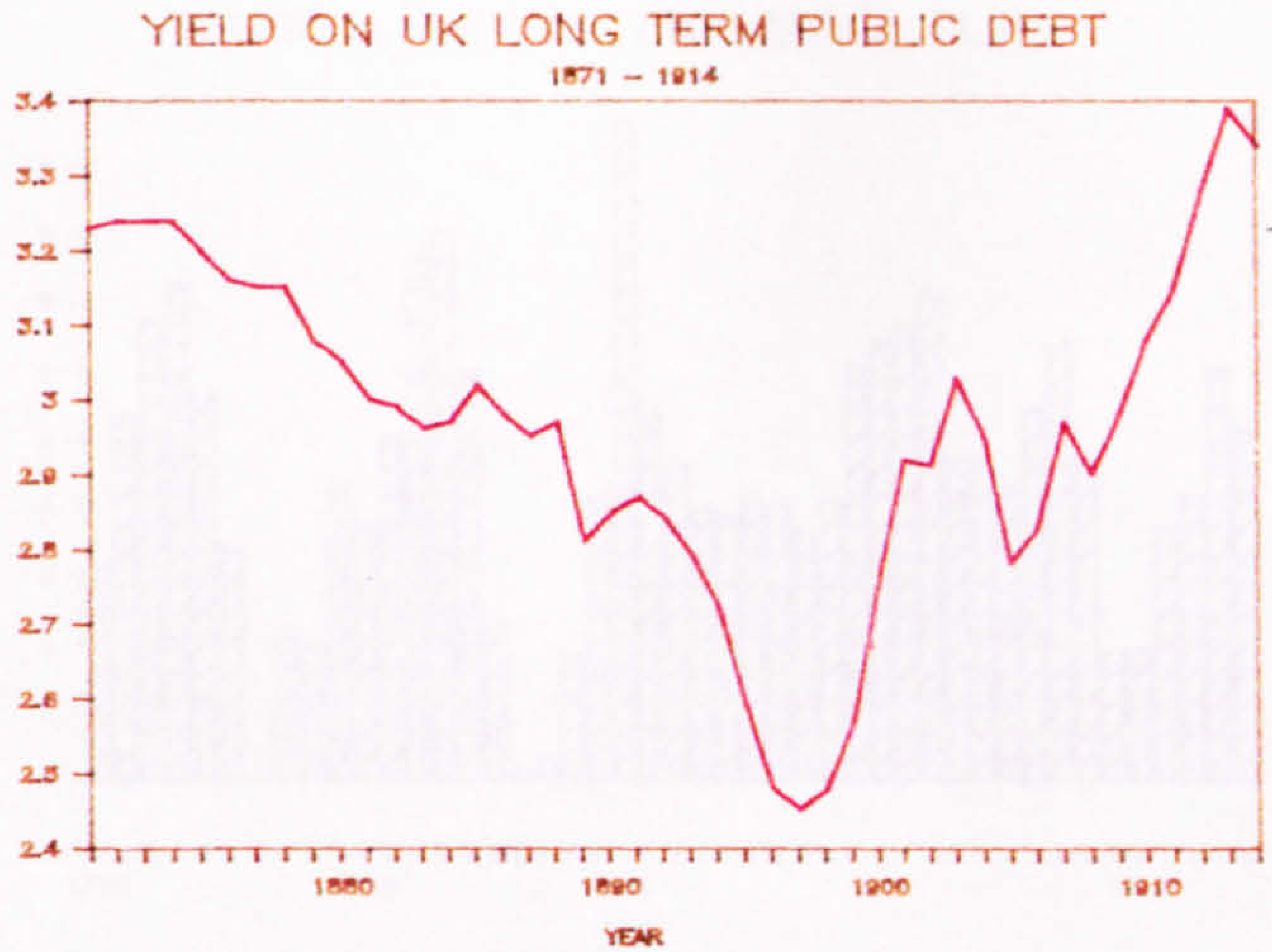


FIG. 1.4



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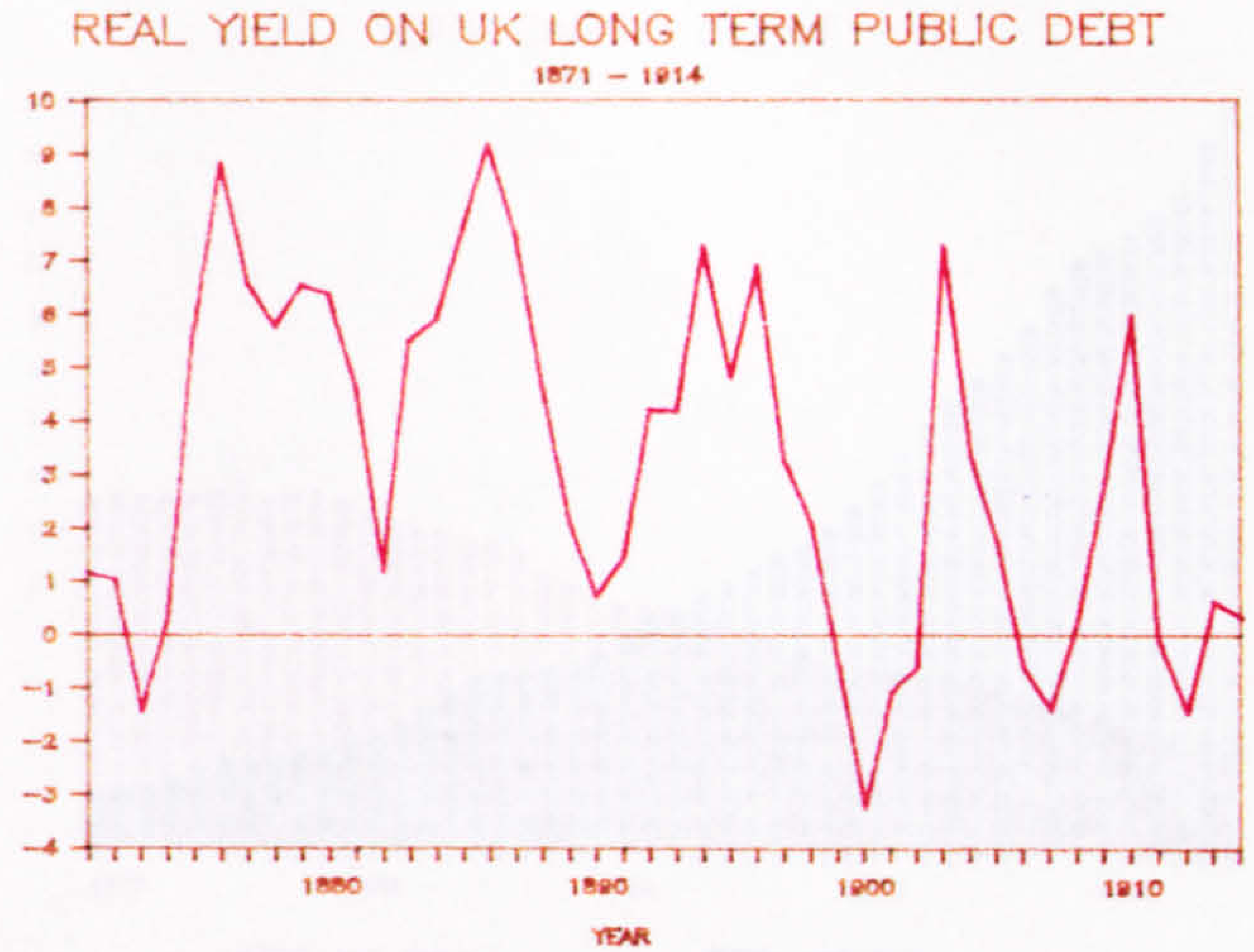


FIG. 1.6

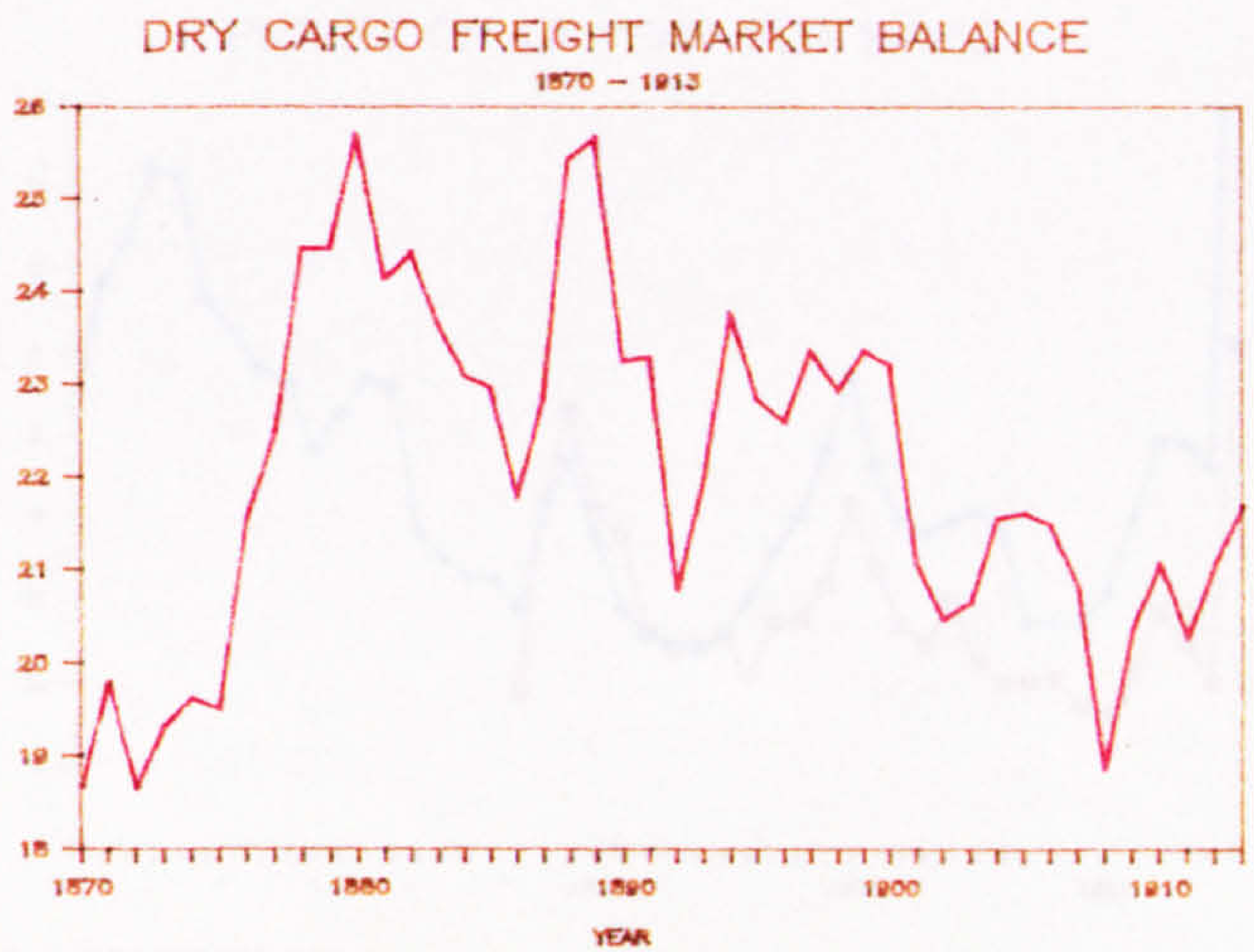


FIG. 1.7

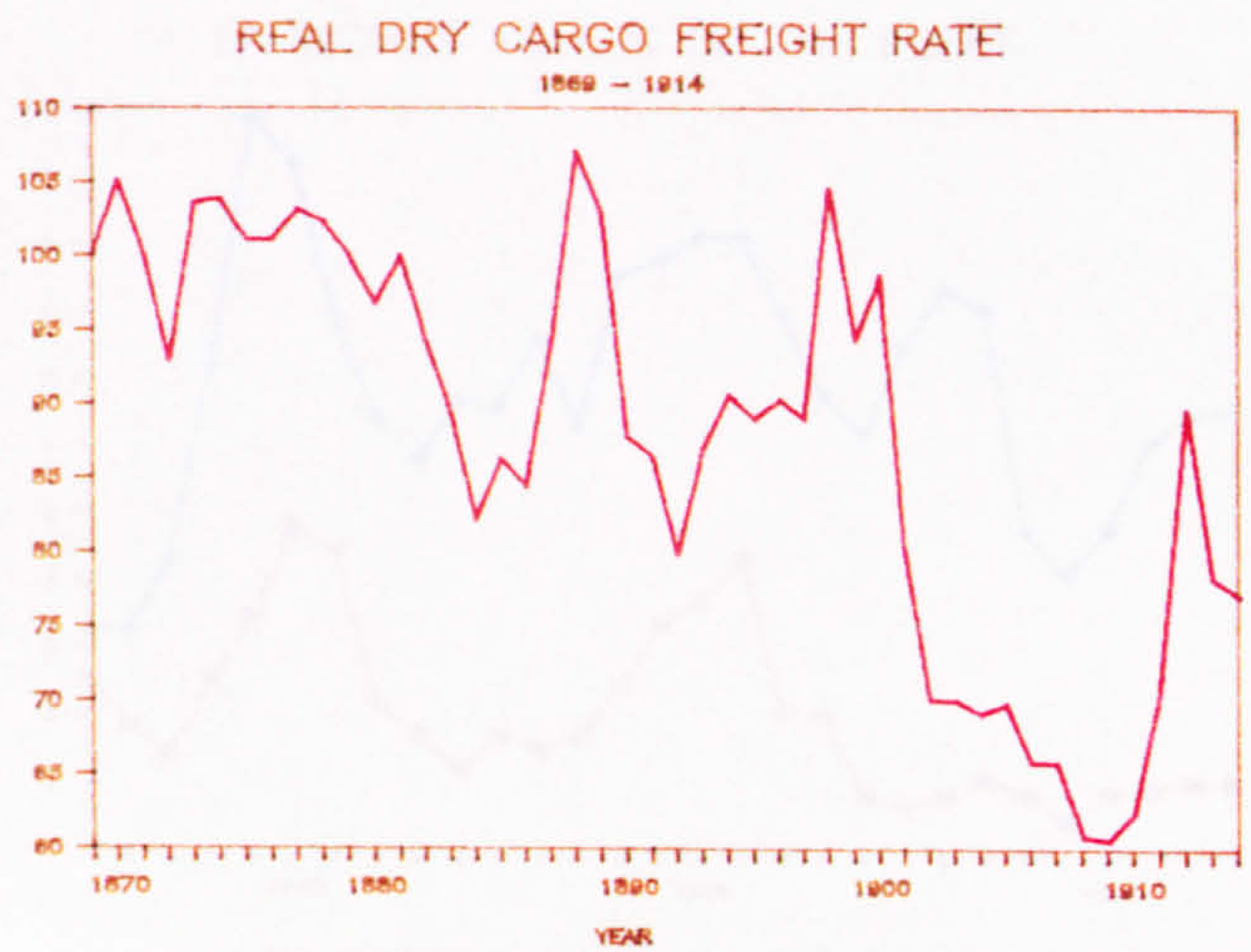


FIG. 1.8

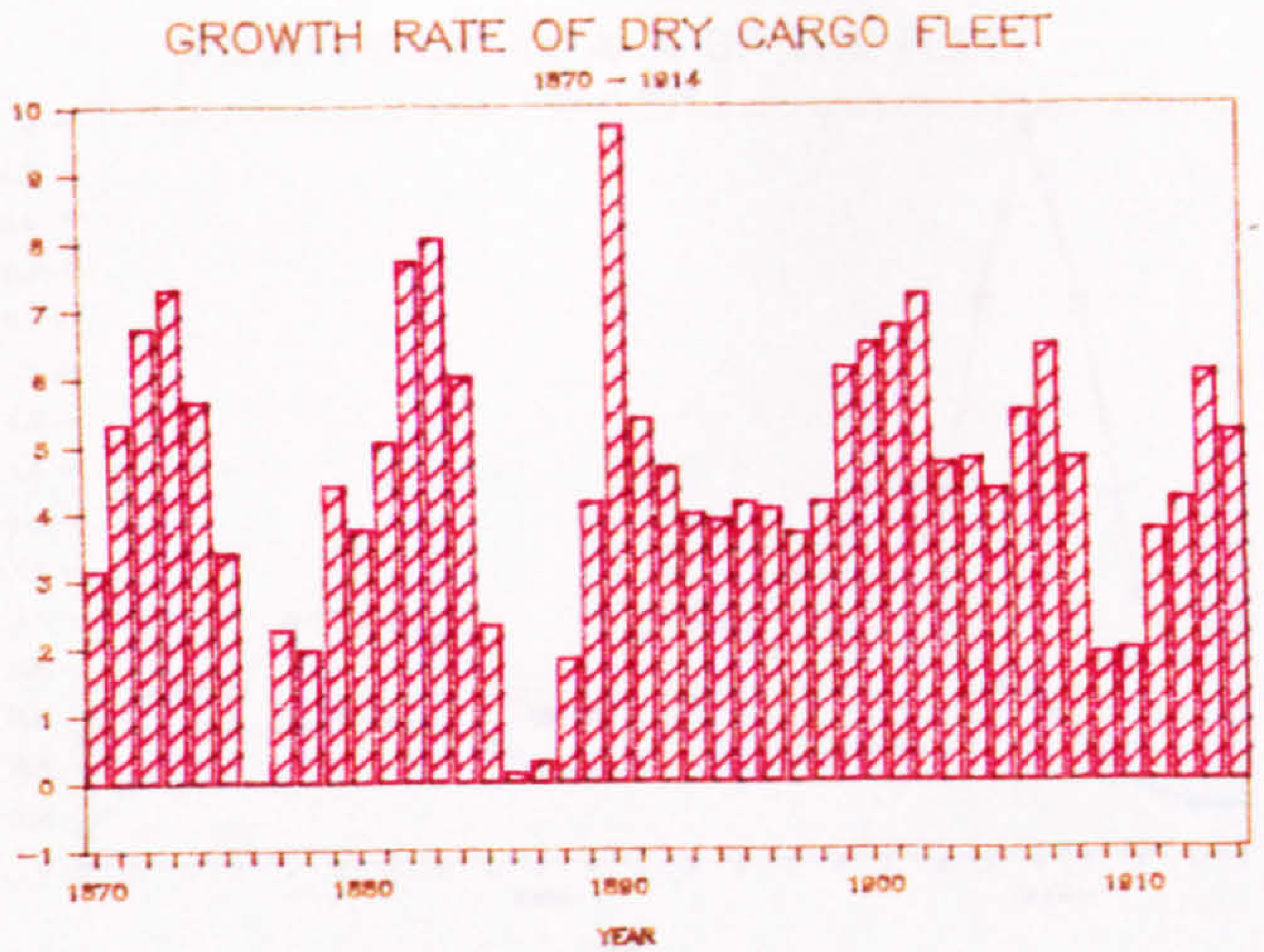


FIG. 1.9

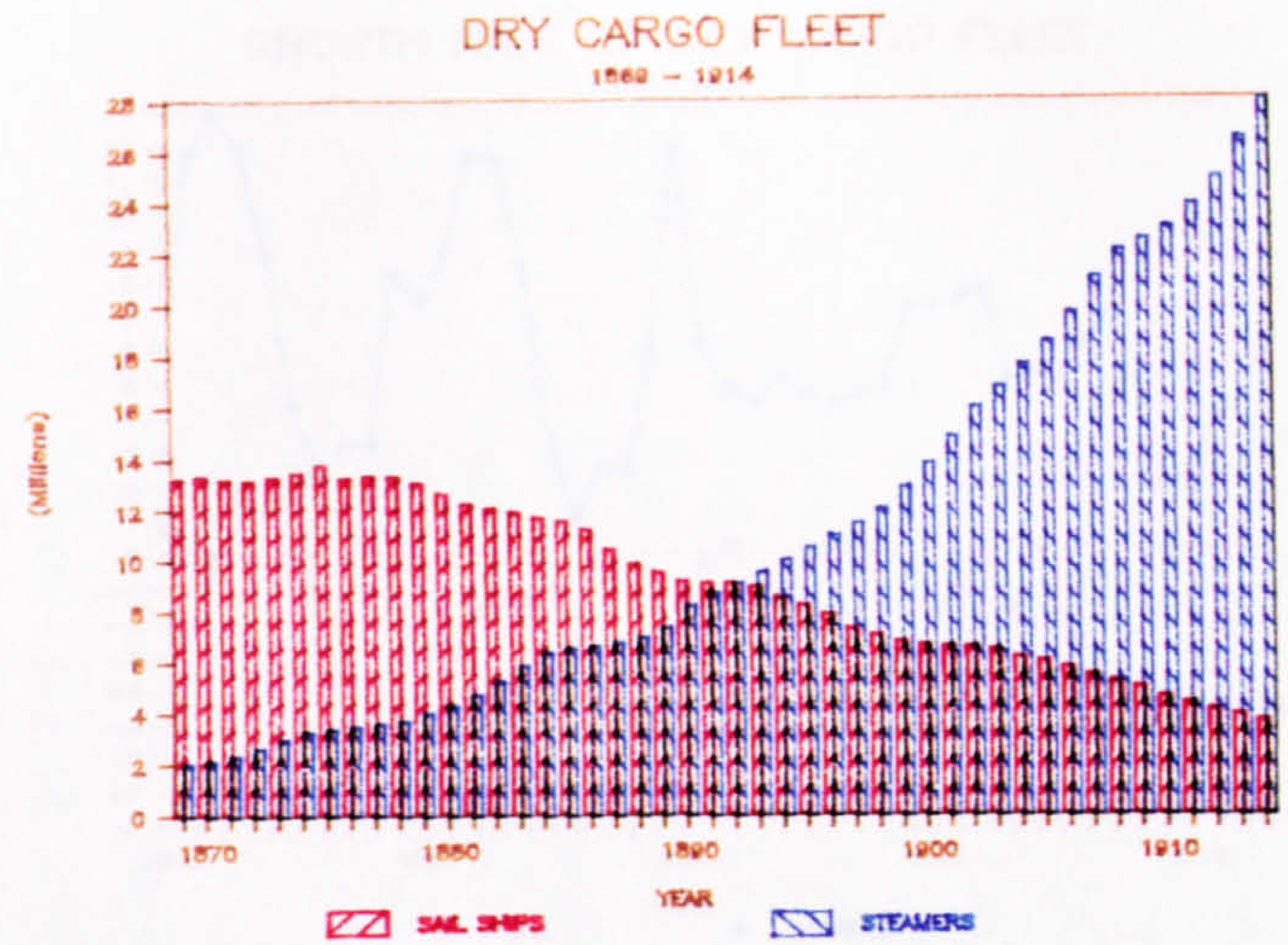


FIG. 1.10

FIG. 1.11

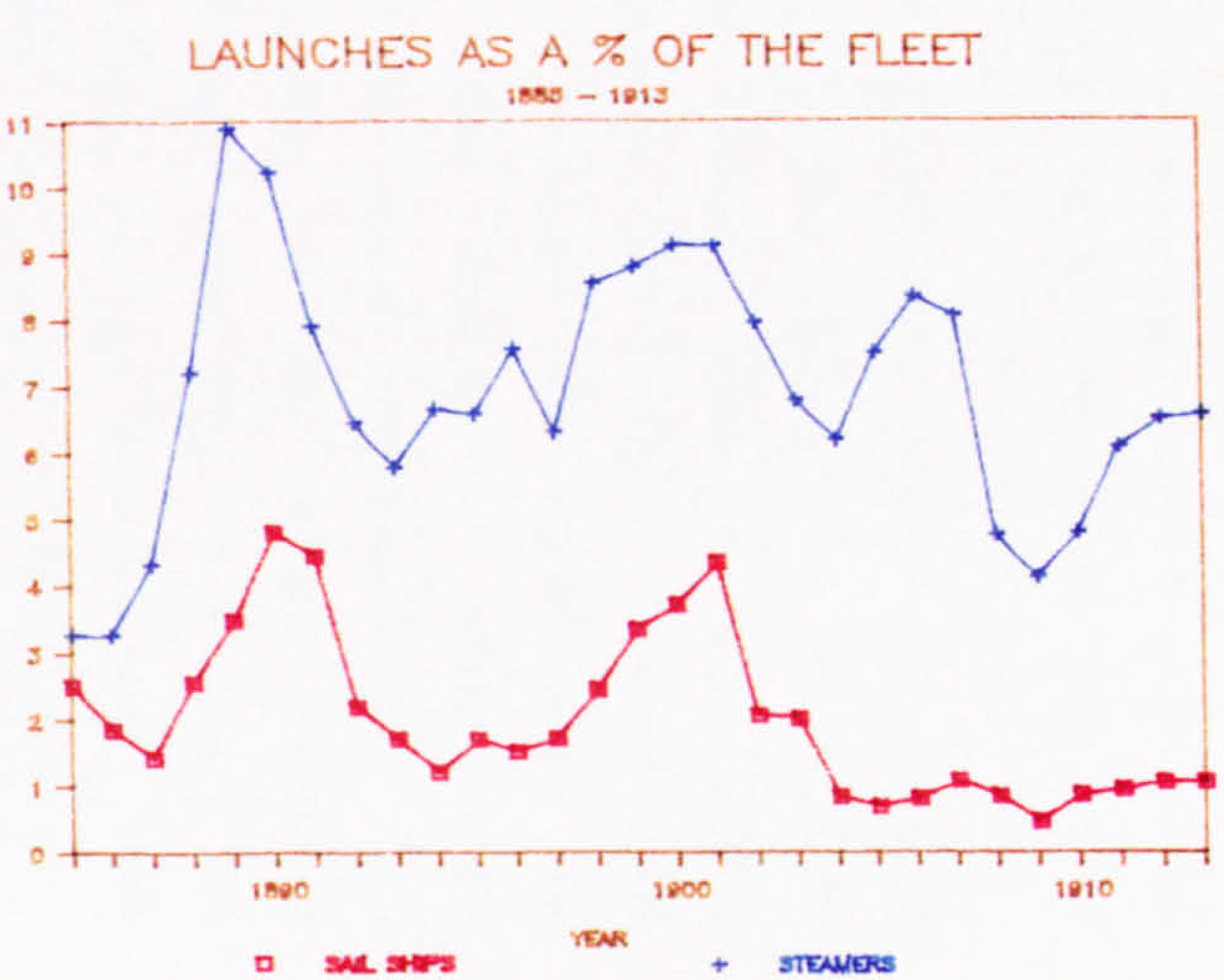


FIG 1.12

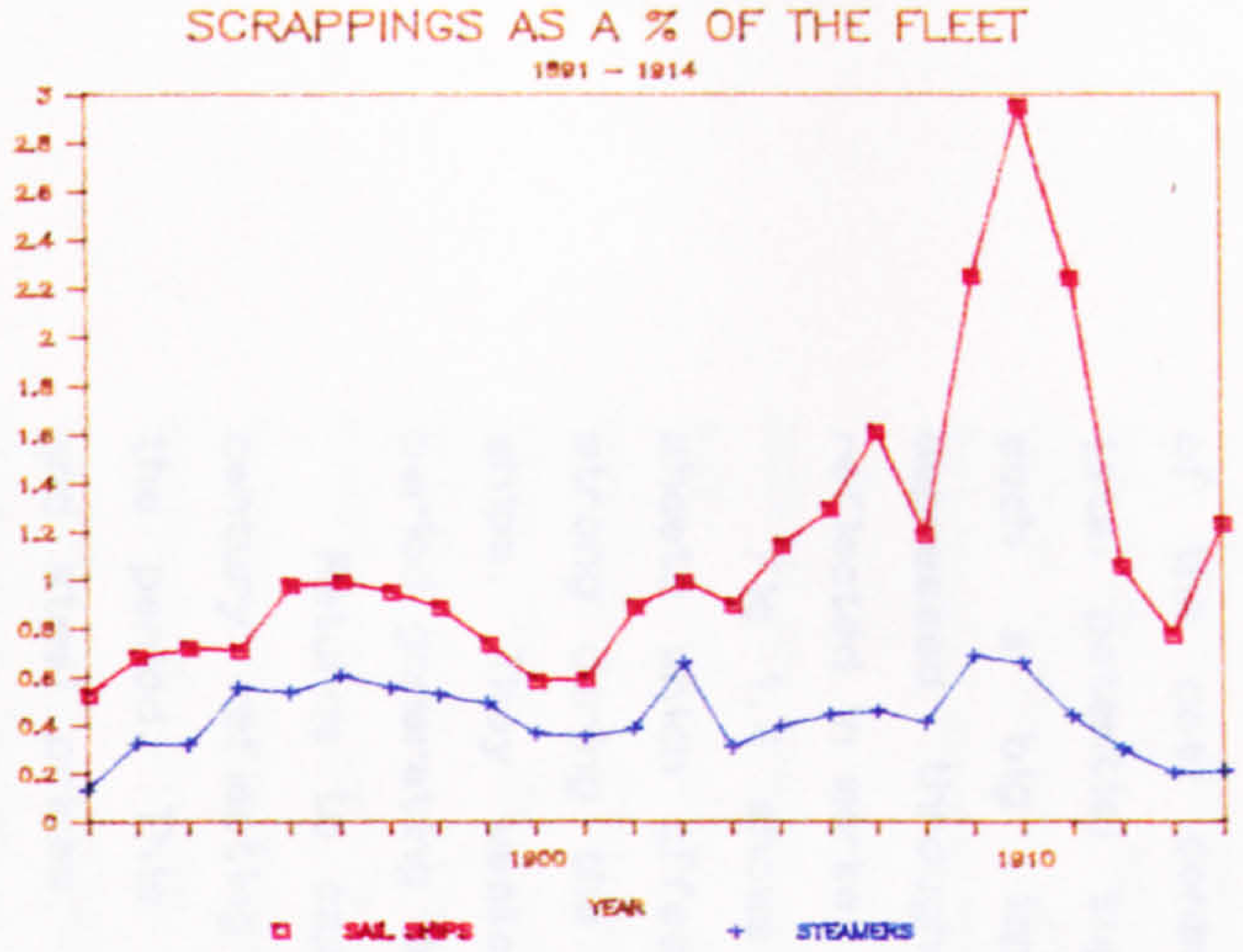


FIG. 1.13

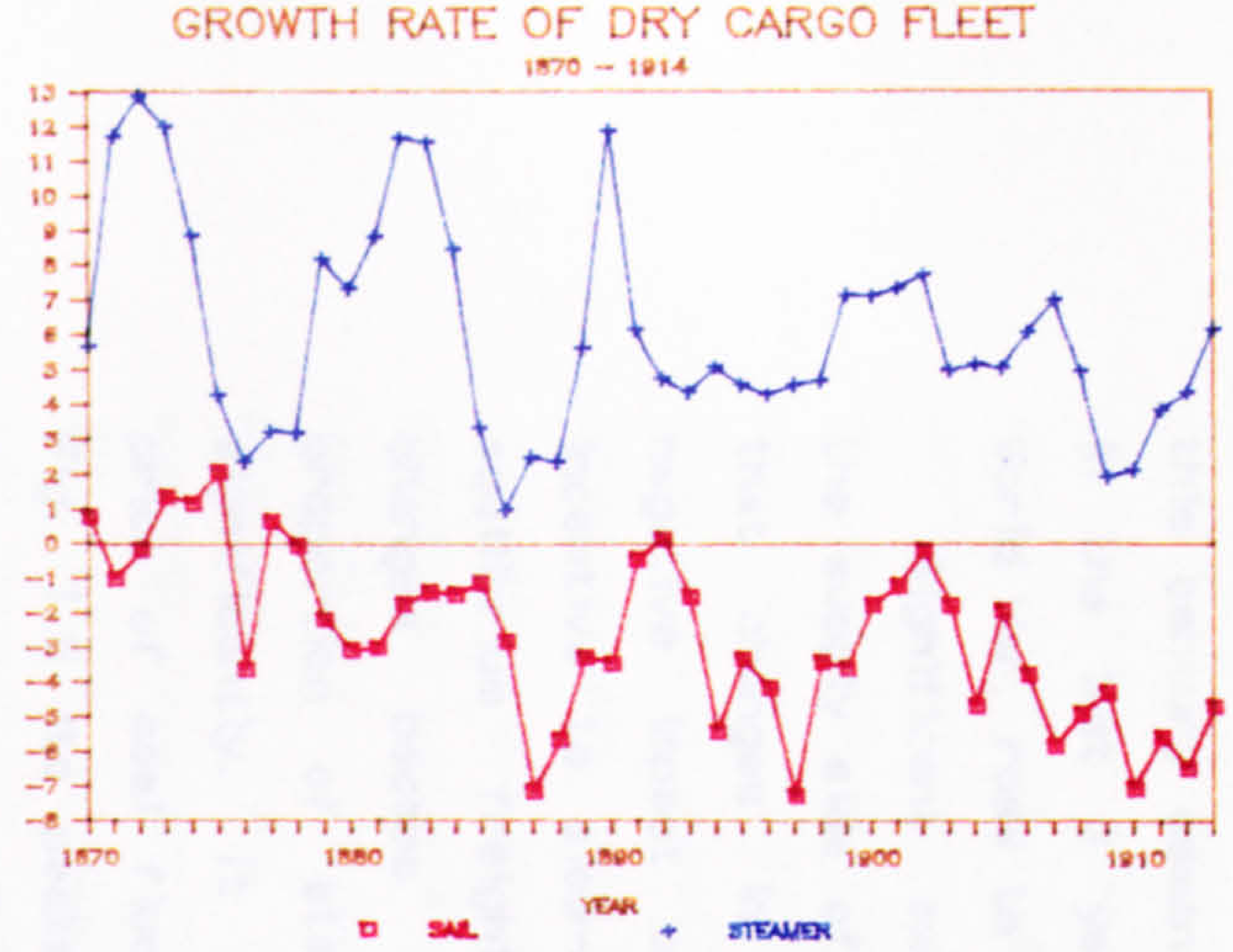


FIG. 1.14

average of 3.4% p.a while in the next decade this increased slightly to 4.6% p.a. In the first decade of this century demand grew at an average rate of 3.8% which in the last 3 years of this period prior to the first World War, rose to 5.6%.

Significant exogenous shocks also occurred through the supply side of the market. The steamer ran on coal so that changes in its price would have a significant, negative impact on the supply of freight through the incentive to slow-steam and in turn this would raise the equilibrium freight rate. The impact of coal price changes became progressively more important as the proportion of steamers relative to sail ships increased significantly. It can be seen from Fig. 1.3 that the price of coal fluctuated widely and as can be seen from Fig. 1.8 its peaks coincided with peaks in freight rates. Bunker prices peaked in 1873, 1890 and 1900. The latter two peaks which occurred at a time when the freight market balance was tight had a significant impact on rates. The 1873 peak which occurred at a time when freight market balance was poor and when the proportion of the coal consuming steamer fleet in relation to the total potential supply was small, naturally did not have such a big impact. Coal prices remained generally depressed throughout the eighties and this was also reflected in market conditions.

Fig 1.4 shows the fluctuations in the price of steel sheets which affect the supply of new ships. Prices were strong during the seventies restraining the supply of new ships. They weakened considerably during the subsequent period generating downward pressure on the market.

Returns to capital declined up to the end of the 19th century reflecting the general deflationary conditions of the period. This deflation is also reflected in the coal and steel prices. Yields began to rise from 1900 onwards as the deflationary era came to an end. Insofar as an increase in nominal returns to capital purely reflects an increase in long term inflationary expectations, ship values will not be negatively affected. On the contrary they will tend to appreciate in line with general inflation, and in the short run they might even increase in real terms as investors tend to switch to real assets as a hedge. However an increase in nominal yields that purely reflects an increase in the real return to capital, will have of course an adverse effect on values as investors will tend to move out of ships until prices have fallen sufficiently so as to raise the expected return to a level which is in line with that offered by other assets. The real return to capital as indicated by the real yield on UK consols (Fig. 1.6) did not show any significant trends over the whole period but exhibited considerable cyclical volatility. The cyclical troughs occurred in 1873, 1882, 1890, 1900, 1907 and 1912. These cyclical troughs in real yields have tended to coincide with peaks in ship values (Fig. 1.11), as suggested by our theoretical arguments. An exception to this is 1907. Furthermore, we also notice that peaks in the real return to capital, which in general occurred during the middle of the decades, have coincided with troughs in ship values.

These movements in the exogenous factors are reflected in aggregate fluctuations in freight rates, market balance, ship values, shipbuilding and scrapping. Aggregate movements in market conditions, are depicted in Fig. 1.7 - 1.14. In theory, these reflect not only the actual movements in external factors shown in Fig. 1.1 - 1.6, but also speculation regarding future external conditions. The latter unfortunately cannot be observed since data on expectations are not available. This is unfortunate, since expectations affect current market conditions so the full story cannot be told without knowing what expectations were at each point in time. Suffice it to say however, that expectations affect the system only through their effect on current ship prices. Once the latter are known, a partial story can be told where only the important link between speculation and ship values will unfortunately be missing.

As a whole, external conditions were most favourable for the shipping industry during the seventies, when the average growth rate in demand for freight was over 7%, steel prices were strong while coal prices reached a very high level during the first part of the decade. Against that we have the general deflation of this period which is indicated by the falling nominal yields and the rising real interest rates and this must have had an adverse effect on values. The secular downward effect on rates and values of this general deflation, was reinforced by the invention of the steamer and the rapid expansion of its fleet size. Throughout the remaining period the market generally continued to follow its downward trend but showed considerable cyclical fluctuations with peaks occuring roughly just before or at the turn of each decade. This to a large extent reflects the fact that the growth rate in demand happened to peak at roughly that time.

The year to year changes in freight rates (Fig. 1.8) reflect changes in the level of demand and fuel prices and also to a large extent changes in the capacity of the fleet. Fluctuations in the latter are shown on Fig 1.9 and 1.10. Changes in the size of the fleet are positively related to ship values. This is because higher values have a positive effect on the supply of newbuildings while at the same time they reduce scrapping.

Fig. 1.11 records the general level of ship prices. We have constructed separate indices for sail ships and for steamers. These have been rebased so as to represent prices in £ per dwt of a 10 year old 3500 dwt sail ship and a 10 year old 5000 dwt steamer. These separate indices are needed for later reference. Appendix 1 contains a full description of how these indices have been constructed. For the time being we are interested in fluctuations in the general level of prices and how these affected the change in the fleet through an expansion in the supply of newbuildings and contraction in scrappings. Fig. 1.11 shows that prices rose strongly in the beginning of the seventies but from then on kept falling continuously up to the end of the eighties in line with external changes and with the exception of a cyclical upturn round about 1880. They rose again strongly towards the end of the eighties peaking in 1889. Then followed a significant depression in values which lasted until the Boer war in the beginning of this century absorbed a significant proportion of the fleet and coincided with an increase in coal prices. Another long and deep recession followed which lasted until 1910 when the market turned and prices begun to follow an upward trend. In 1915 they trebled as the War send rates sky rocketing. There was a milder speculative increase of prices round about 1904. Figs. 1.12 and 1.13 show the fluctuations in shipbuilding and scrapping which indeed mirror these developments in prices as we would expect.

Supply of new ships and therefore actual deliveries of both steamers and sail ships rose exactly in line with actual movements in values peaking at or after the same year as prices. Scrapping on the other hand moved in a countercyclical way, peaking during the bottom of the depression and falling as soon as values increased. Even the small speculative increase in values of 1904 is reflected in these charts.

Fig 1.14 shows the annual percentage changes in the fleet which reflects the excess of shipbuilding over scrapping. It follows from the above, that the growth rate of the fleet tended to increase when values were strong, while it tended to fall when values were weak. This is clear from the chart.

Annual changes in the fleet and in demand lead to changes in the freight market balance (Fig. 1.7) which is here defined as the ratio between demand and the fleet. These we expect should be reflected in fluctuations of freight rates and indeed they do as a comparison of Fig. 1.7 and 1.8 illustrates. The correlation is not expected to be perfect because the fleet does not completely determine supply. Changes in bunker prices create an incentive to slow steam and this has an independent effect on rates. Indeed by comparing Fig. 1.3, 1.7 and 1.8 it can be seen that deviations of rates from freight market balance are easily explained by changes in fuel prices.

It can be observed that peaks in demand tend to coincide with peaks in coal and to a lesser extent steel prices and with troughs in the real return to capital. This adds further to the upward pressures generated by the strong demand. This positive correlation between growth rates in demand, bunker and steel prices and the negative correlation with real return to capital is empirically quite stable and can be observed throughout the whole period of the study including modern times. These correlations in the movements of the external factors most likely reflect structural features of the world economy and the type of shocks to which it was subjected. The implication for the shipping industry however is that the market tends to be volatile as favourable demand shocks tend to coincide with additional favourable supply shocks that both tend to push rates and prices in the same direction. Had the correlation between demand and supply shocks been negative, the industry would have been more stable as the positive effects of a demand shock say, would have been partly offset by negative effects of a likely simultaneous unfavourable supply shock.

Steam and Sail Ships

The secular downward trend in freight rates that we observe during this period, was to a large extent due to the appearance of the efficient steamer. Having looked at the aggregate fluctuations in rates, prices and the total fleet, as induced by actual movements in external factors and speculation, we can now consider the individual and divergent trends in the sail and steamer sectors.

Fig. 1.10 shows the independent developments in the size of these two constituent parts of the fleet. Figures are available from 1869 onwards. During that year the sail fleet amounted to 13.3 million nrt while the corresponding figure for steamers was 2.0 million nrt. When analysing the significance of these figures one must allow for the fact that one "steam ton" represents a much higher amount of transport capacity than a "sail ton", the ratio being conventionally taken as 3:1. This was because the steamer was able to maintain a high speed of 10 knots under all weather conditions whereas the most efficient sail ship would only make about 8 knots under the most favourable conditions. Using these ratios we can work out that in 1869, sail ships represented more than 85% of the total fleet in nrt terms but in effective capacity terms they actually represented something less than 70% of the potential supply. This was still a very significant proportion of the total fleet.

During the early part of this period, the steam fleet was so small that demand could only be satisfied if a significant proportion of the sail fleet was utilized. Thus rates had to remain strong in order to attract the inefficient sail ships out of lay-up and into the market. Prices of steamers were firm reflecting the high rates and their higher productivity. This high level of prices was bringing forward and increasing supply of newbuilding steamers which were willingly bought by investors because of their high profitability. At the same time there was little incentive to scrap highly valued steamers. Thus the steam fleet was growing at a much faster rate than demand during the first years of this period.

This was causing a gradual secular decrease in rates. Before the appearance of the steamer, rates were oscillating around a higher average level which was determined by the fact that inefficient sail ships had to earn a return on their building cost. The secular decrease was pushing rates below this high level so that building of new sail ships at prices which would have been acceptable to both the investor and the builder was no longer feasible. Thus, as Fig. 1.12 illustrates, building of new sail ships dropped to an insignificant level during the early part of this century.

Parallel to the secular drop in rates, there was also a secular drop in prices of sail ships as shown on Fig. 1.11. The sharp increase in prices during the early years of the Great War was an aberration which was a mere reflection of the abnormal effects of world wars on demand for shipments. The downward trend in sail ship prices continued after the Great War when the market returned to more normal conditions. The drop in rates and prices of sail ships encouraged higher scrapping which was indeed on an upward trend throughout the period under review as Fig. 1.13 illustrates. Thus, very soon scrappings and losses - which were considerable - exceeded the volume of new construction and the sail fleet began to decline. This decline is shown on Fig. 1.10 and Fig. 1.14.

With the secular drop in rates, prices of steamers also began to decline as can be seen from Fig. 1.11. However rates and prices were still at a high enough level to encourage the construction of newbuildings and deter scrapping of efficient steamers. Indeed as Fig. 1.12 and Fig. 1.13 show, construction of new steamers was maintained at a high level throughout this period while scrapping was minimal. This of course implied a rapid growth rate in the size of the steam fleet which contrasts with the rapid decline of the sail fleet as shown on Fig. 1.10 and Fig. 1.14.

The secular drop in rates was caused by the rapid expansion of the steam fleet. Eventually rates had to drop to a level where they would force down the price of steamers sufficiently enough to depress the supply of newbuildings and encourage scrapping so as to bring down the growth rate of the fleet in line with that of demand. At that low level of rates the sail ship could not survive. Fig. 1.11 shows the price per dwt of a 3500 dwt iron sail ship and a 5000 dwt steamer. It must be remembered that within a particular sector, smaller sized ships command a higher price per dwt than bigger vessels. With this in mind we can infer from the chart that ever since 1887 a "steam ton" already commanded a premium over a "sail ton" because of its higher effective capacity, lower insurance charges and in spite of the higher running costs of steamers. These higher costs were due to the fact that the steamer required a higher number of crew per dwt and in addition it had to pay for its fuel while the sail ship did not. It seems however that the positive effects of the higher productivity, outweighed the negative effects of the higher costs reducing the cost per ton-mile delivered.

The existence of a premium in the price of steamers would not on its own however have been sufficient to cause an expansion in the steam fleet. Additionally, the extra profitability and the premium it implied had to be strong enough in order to cover the extra costs incurred in building steamers rather than sail ships. One can imagine a situation where the cost of building steamers was so high as to prevent their appearance in spite of their extra efficiency. This however does not seem to have been the case as already by 1887 when the premium was small, many more steamers were being built than sail ships.

From the time the steamer made its appearance the sail ship was doomed. Only a big increase in fuel costs or in the costs of building steamers could have prevented this. The steamer was efficient enough so that it could earn a good return on its building cost at rates which the sail ship could not. Thus rates could fall to a level where profits and prices of steamers would be strong enough to bring forward enough supply of new steamers to satisfy the growing demand and to fill the gap left by the disappearing sail ship. The drop of rates to an uneconomic level for the sail ship was unavoidable. If rates tended to rise to a level where sail ships could survive, this would strengthen steamer profits and prices to such an extent that the steamer fleet would grow so rapidly as to ensure that this rate could not be maintained.

After years of obsolesence, the merchant sail ship reappeared in the 1980's when high oil prices led to the construction of awkward looking modern ships which combined sail and oil fuel propulsion.

1.2.3 The interwar dry cargo market

After the first World War the shipping markets were subjected to a series of severe deflationary shocks which caused the most serious and deepest depression of the whole period under review. Between 1913 and 1938 it is estimated that that volume of seaborne trade rose only by one-third. The coal trades which generated a significant proportion of the total demand where particularly depressed as oil continued to make inroads into the energy markets. At the same time the fleet grew by over 50% and in effective capacity terms much more, owing to higher speeds and other technological improvements.

During the Great War however, the market enjoyed a fantastic boom. Freight rates increased over 10 times between 1914 and 1918. This was due to a combination of a demand and supply factors. The war operations of 1915 brought a huge reduction of 6% in the size of the fleet as the belligerents bombarded each others' ships. At the same time demand for war related transport increased significantly. In addition, the productivity of the fleet dropped considerably as ships came under government control through long term time charters. The employment of the fleet was thus no longer determined by profit maximizing considerations which create an incentive for efficient utilization, but by the strategic needs of the waring parties. Other factors such as widespread market rationing of available resources, the increase in fuel prices which created an incentive to slow-steam, and the increase in war risk related insurance premiums also contributed to a rise in rates. Parallel to the rise in rates there was a sevenfold increase in prices between 1914 and 1919. We estimate that the price of a 10 year old 5000 dwt steamer rose from £23000 in 1914 to £164000 in 1919. Fig. 1.21 shows that between 1915 and 1919 the real yield on UK consols became negative, a phenomenon which was a natural consequence of the war. This further boosted the portfolio demand for ships and their values.

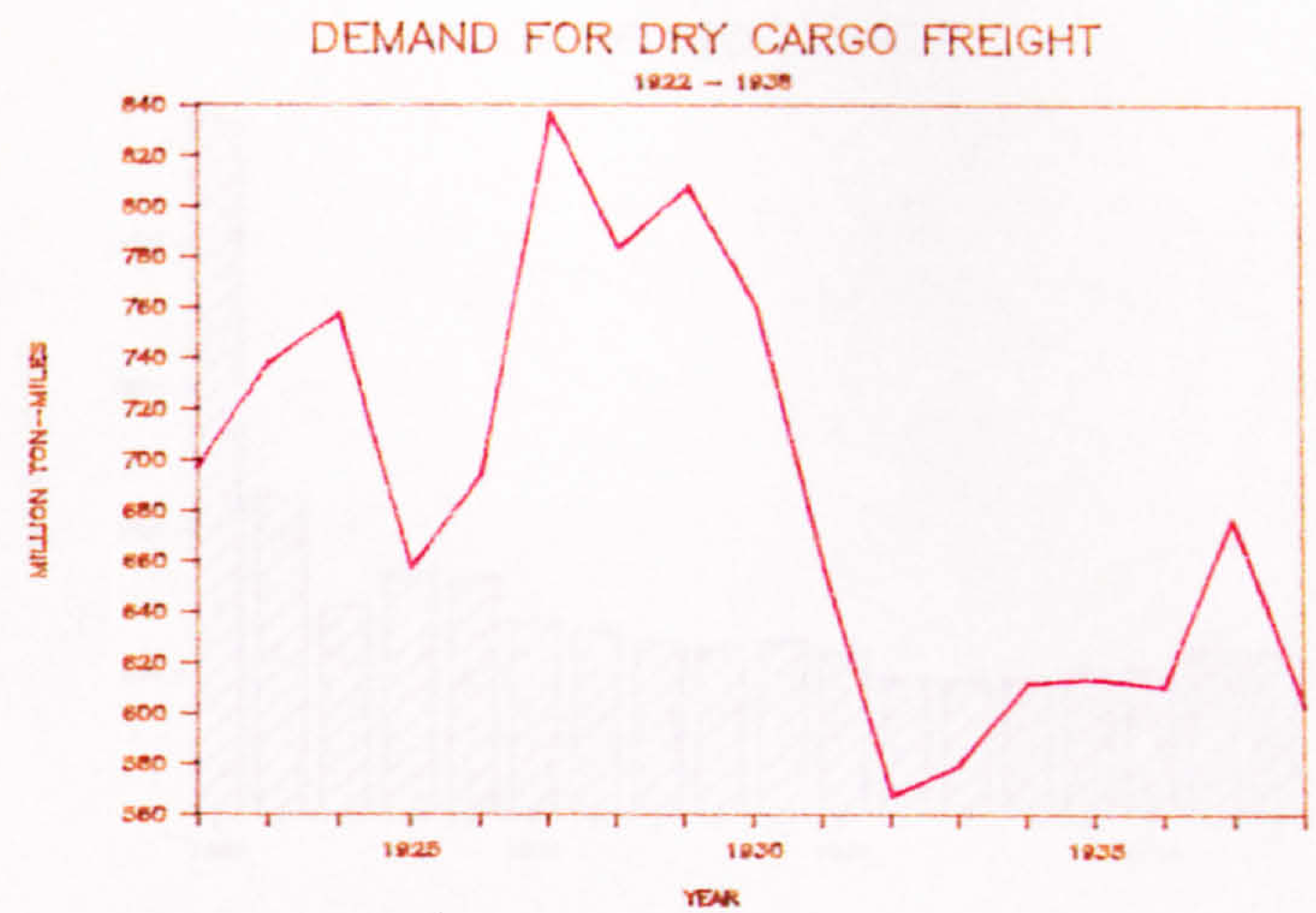
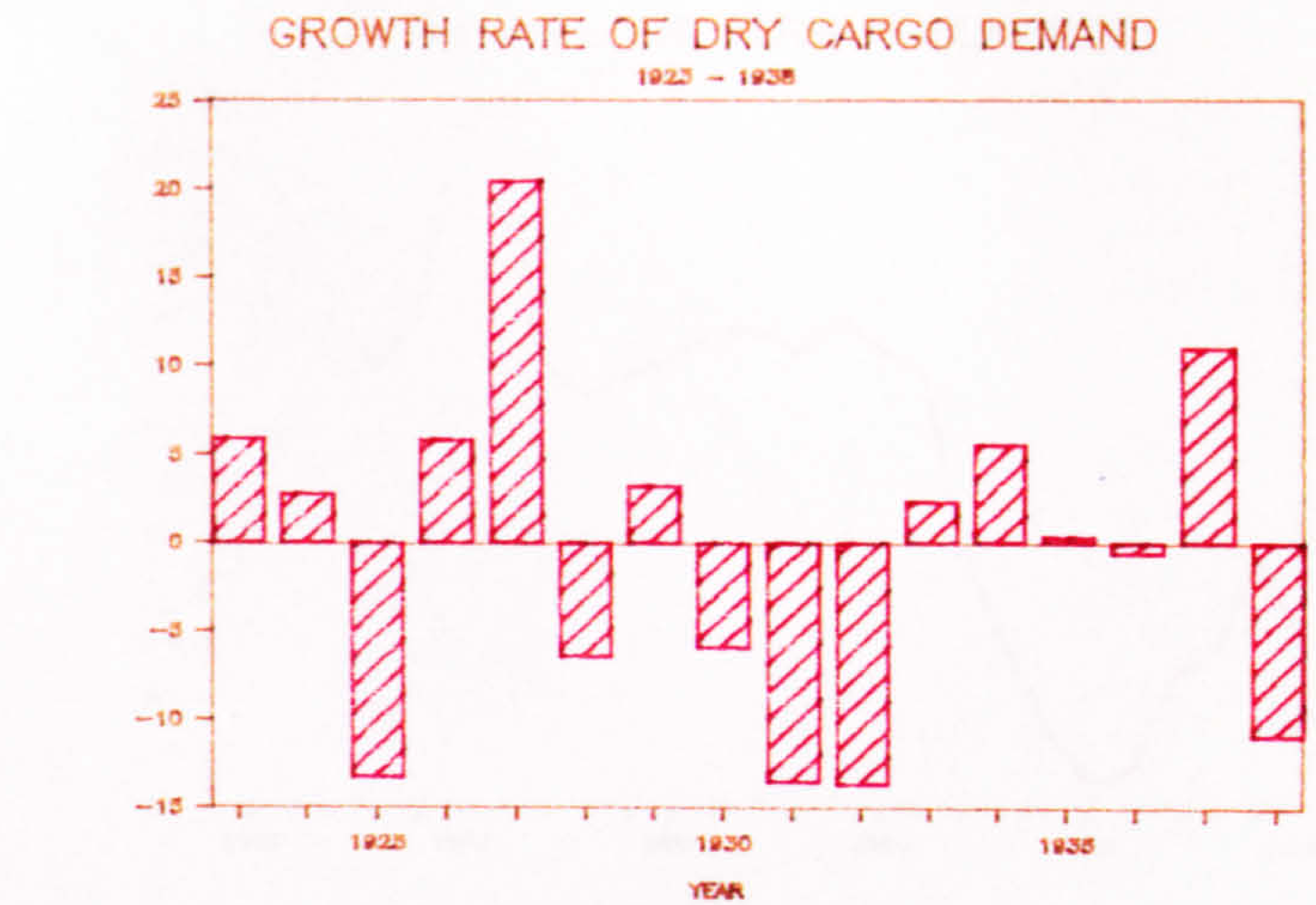


FIG. 1.15



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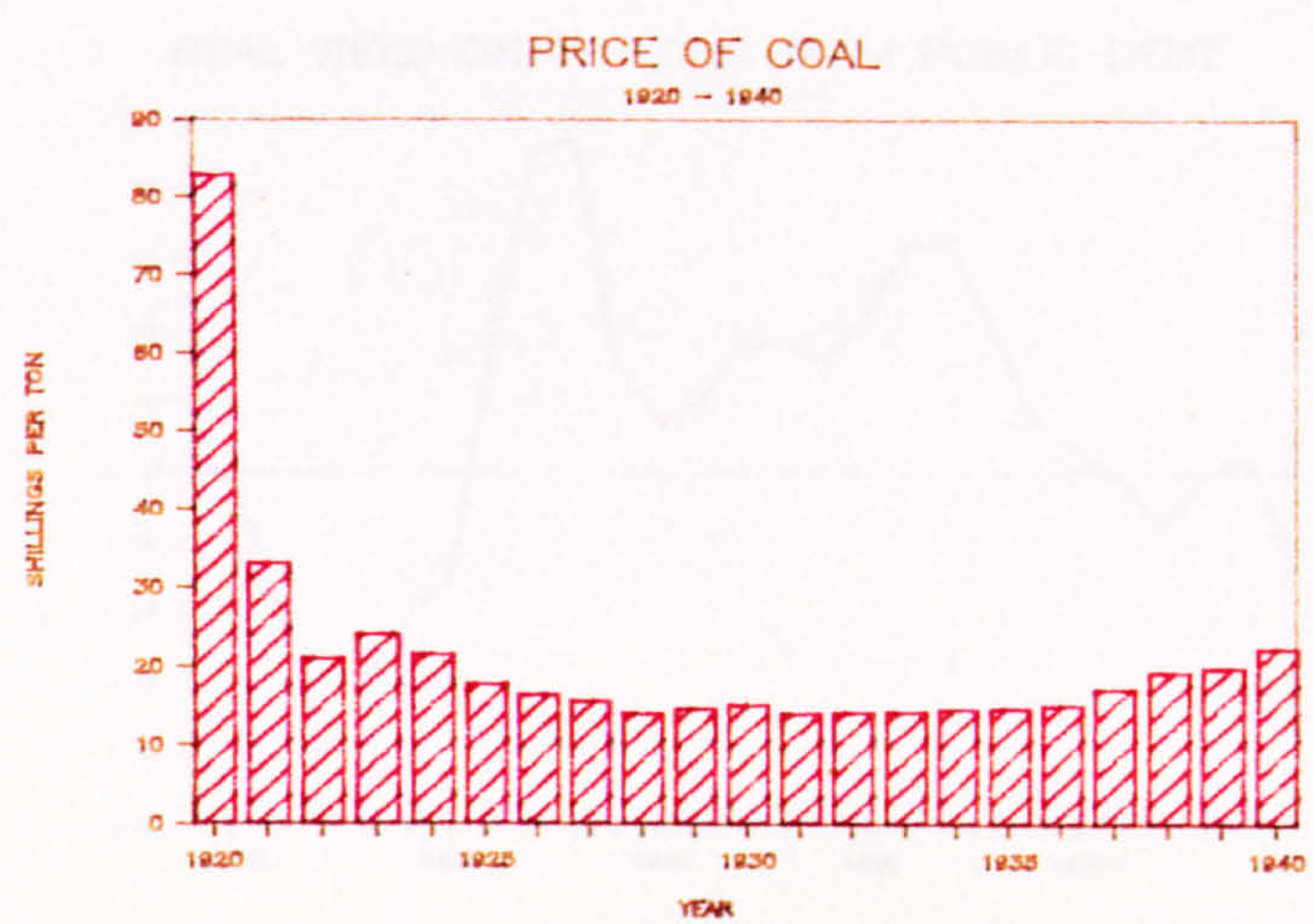

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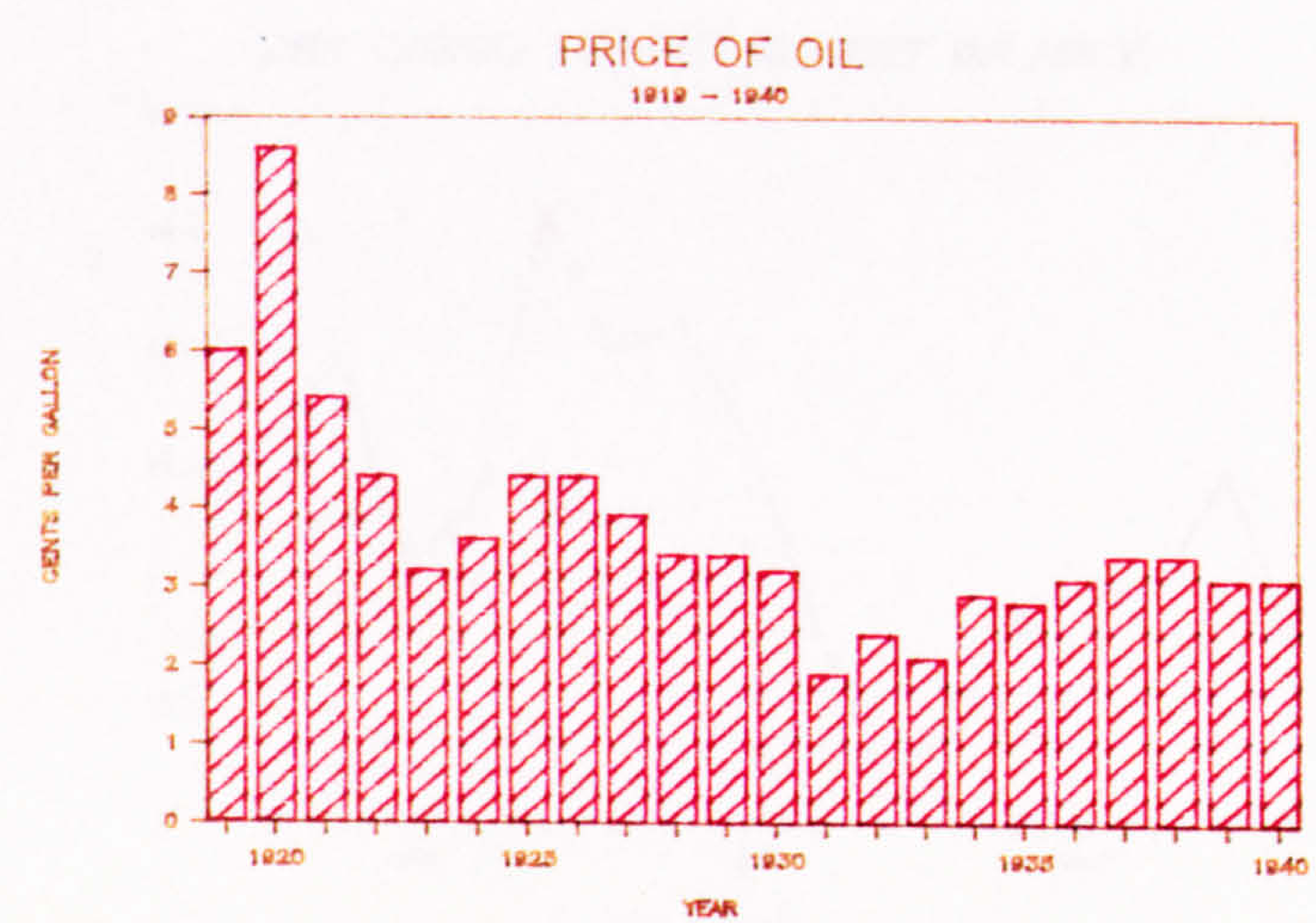
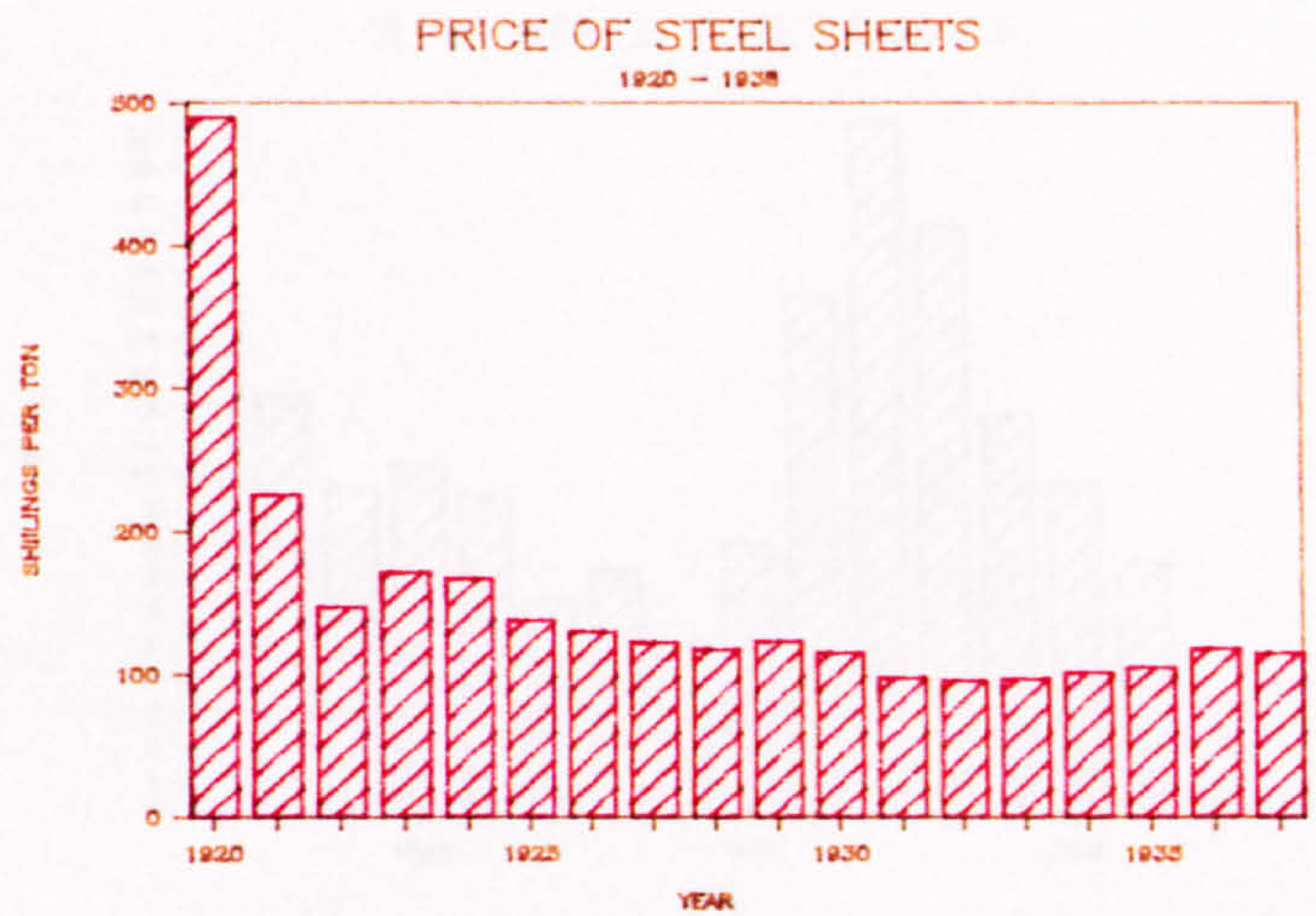


FIG. 1.18



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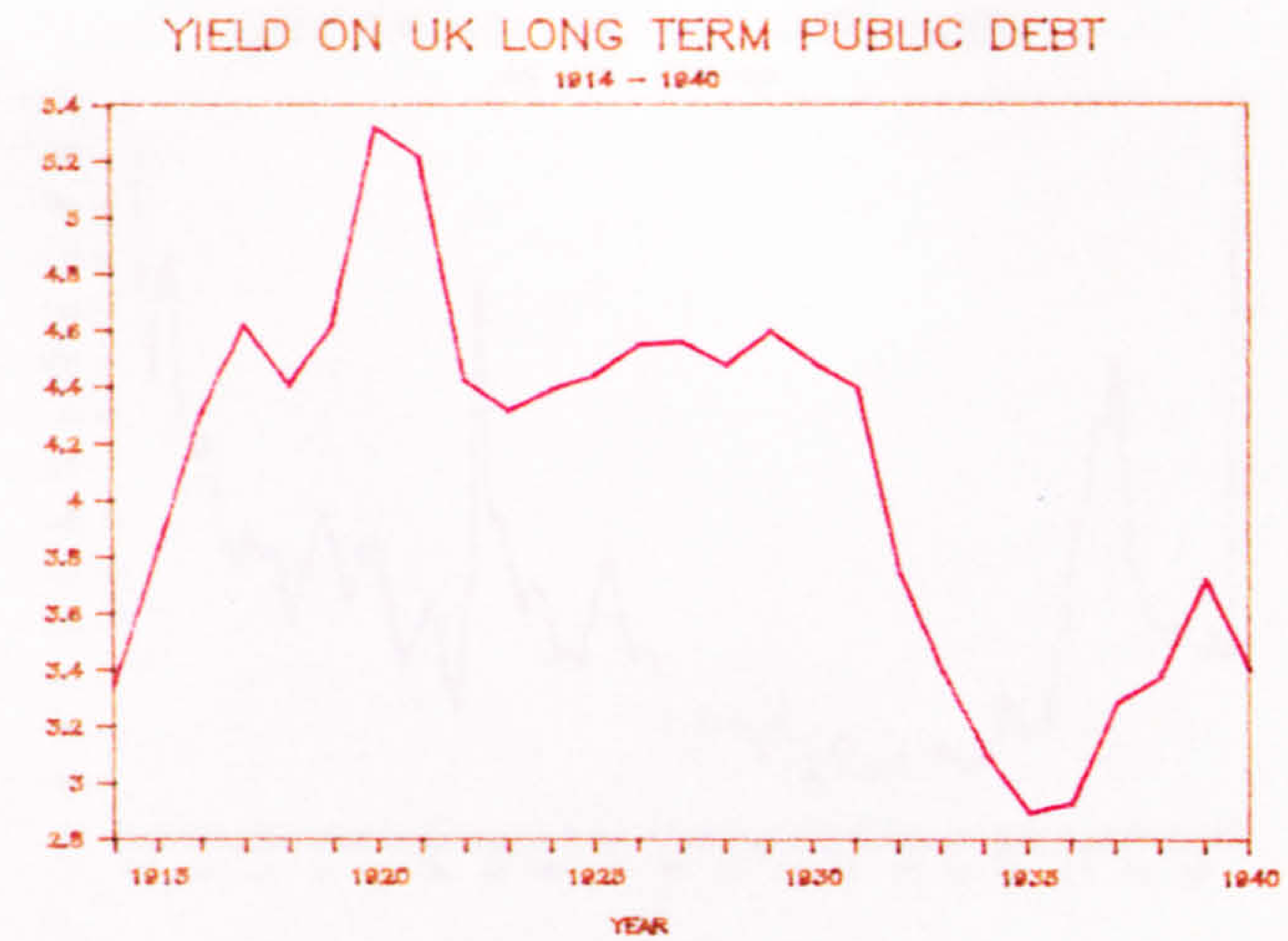


FIG. 1.20

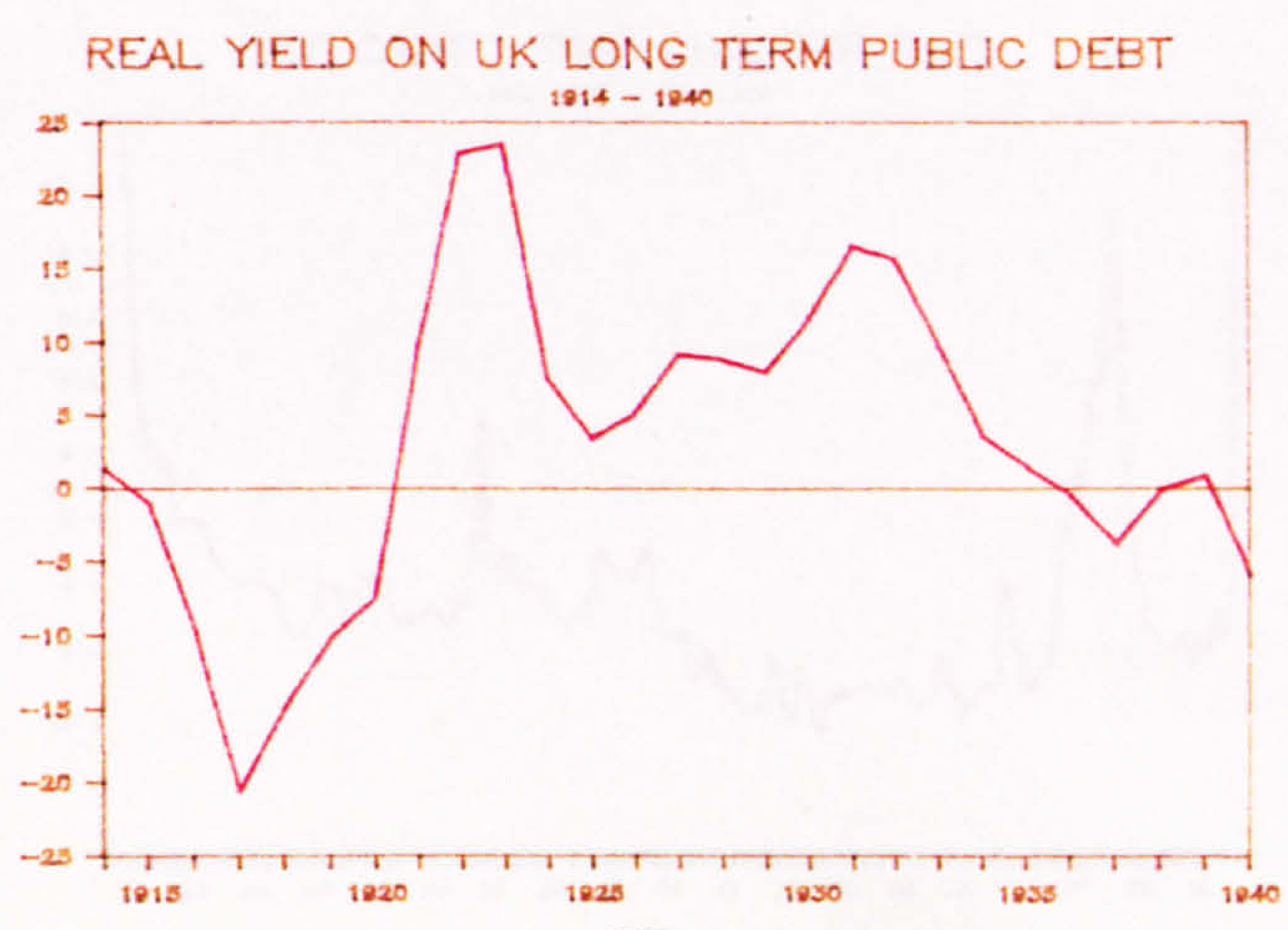
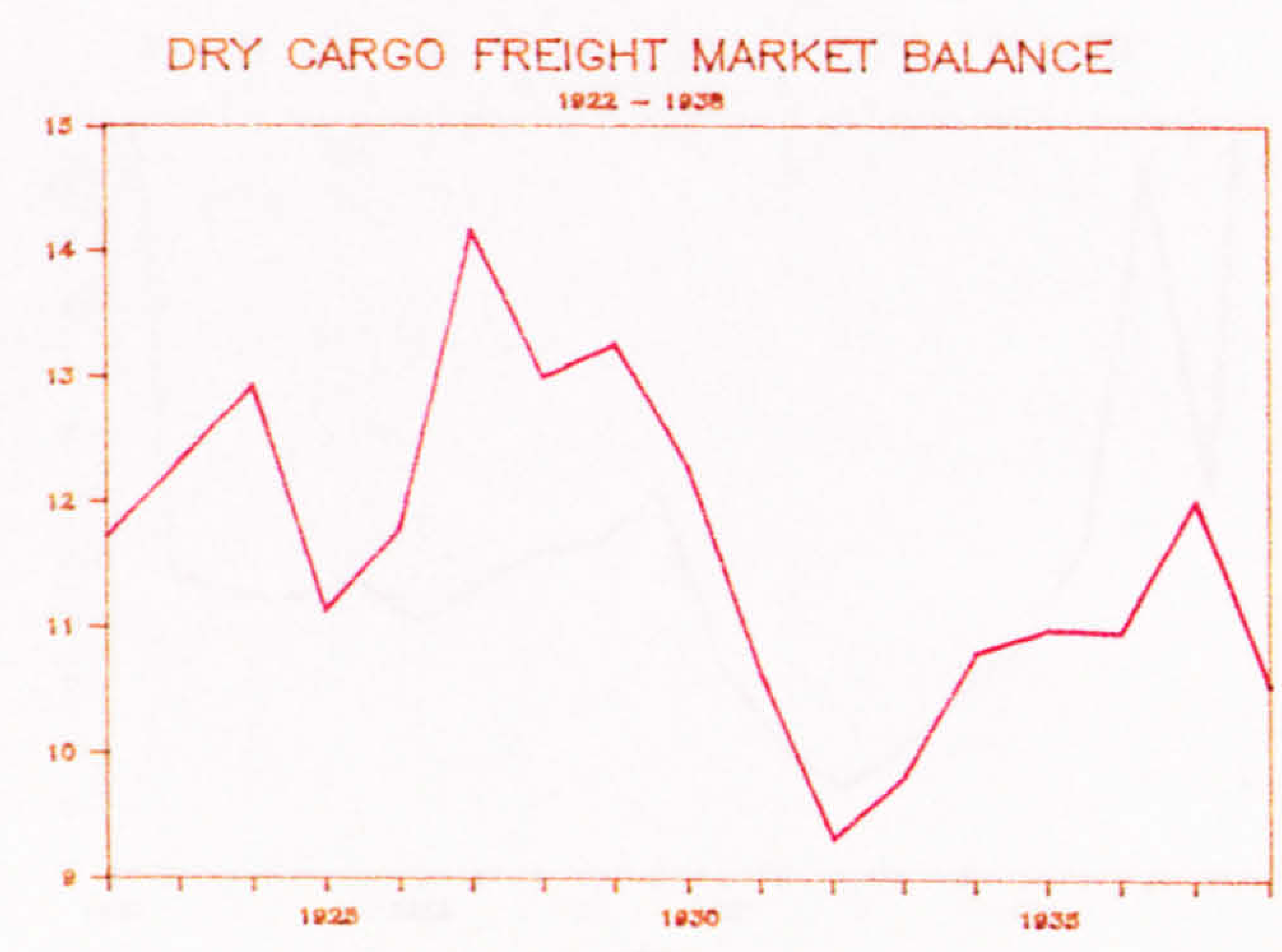


FIG. 1.21



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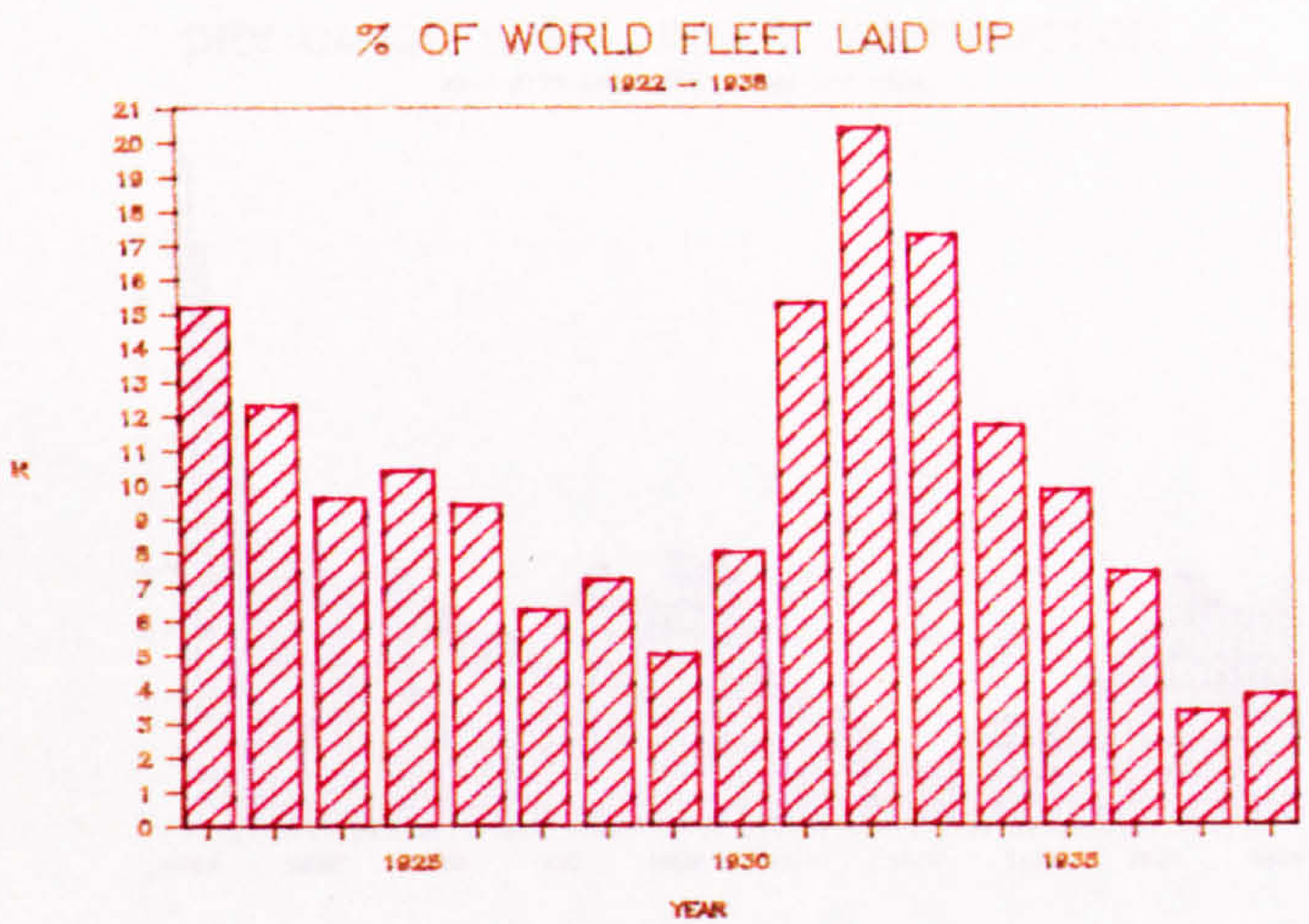


FIG. 1.23

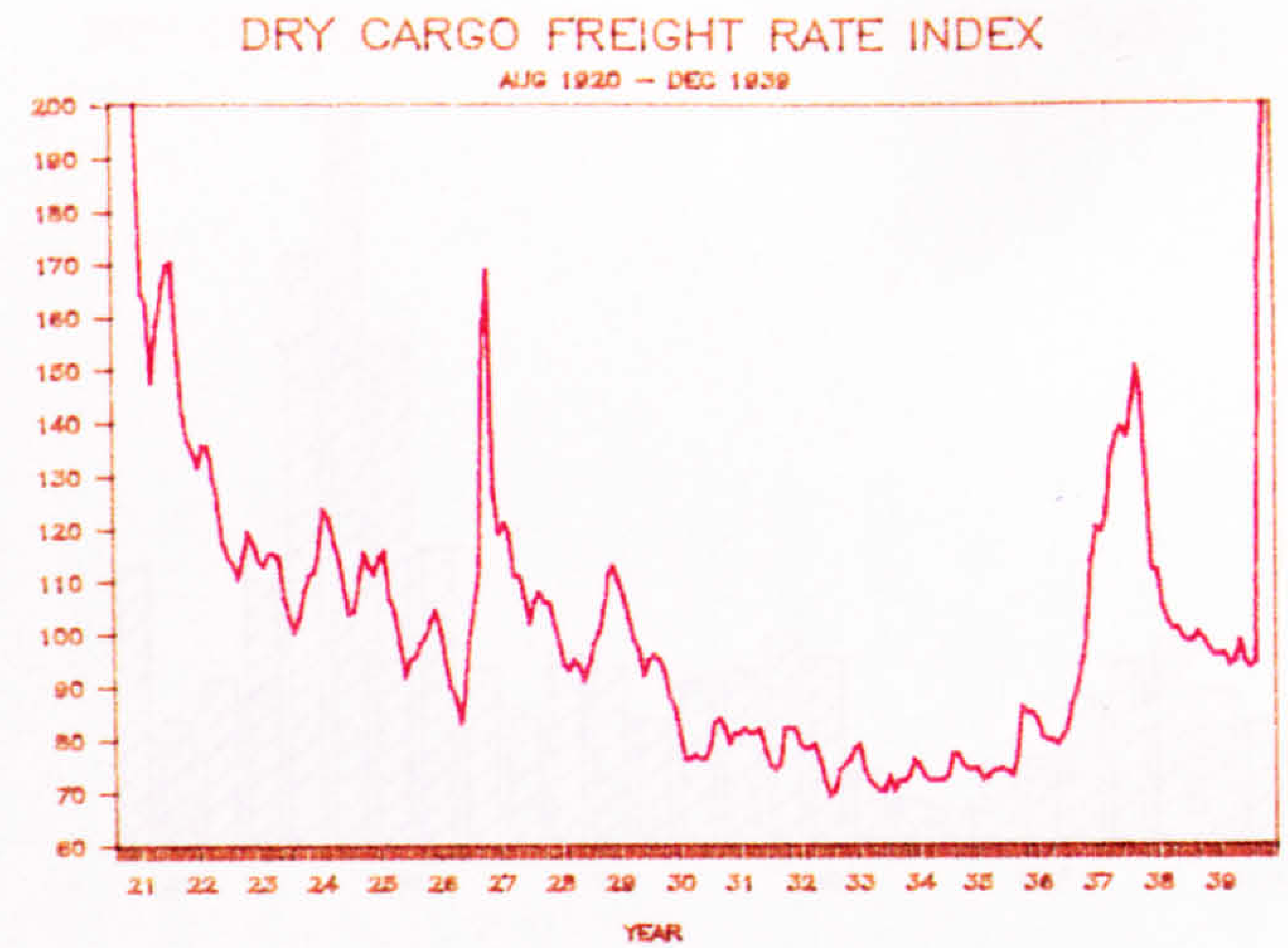


FIG. 1.24

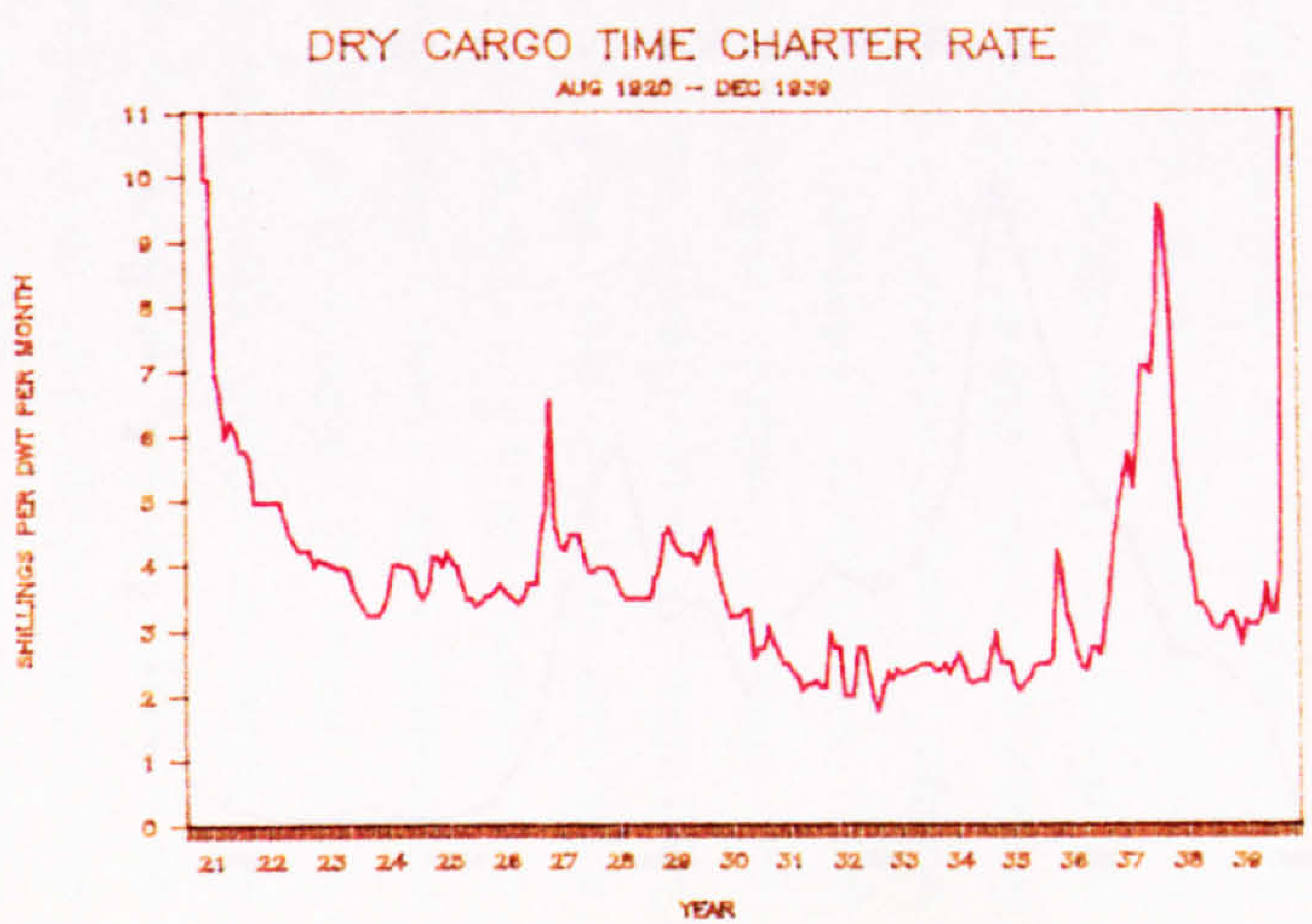


FIG. 1.25

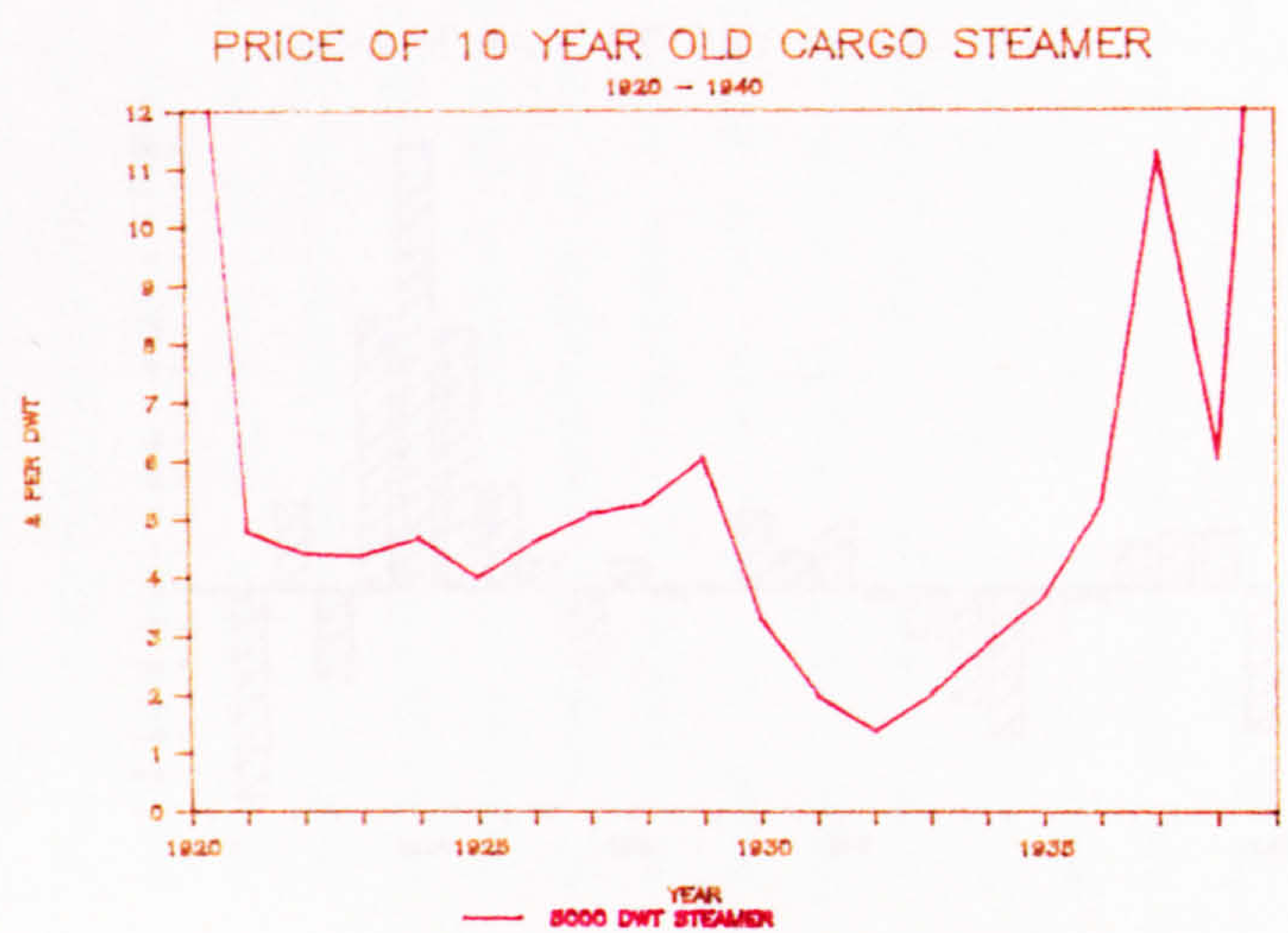


FIG. 1.26

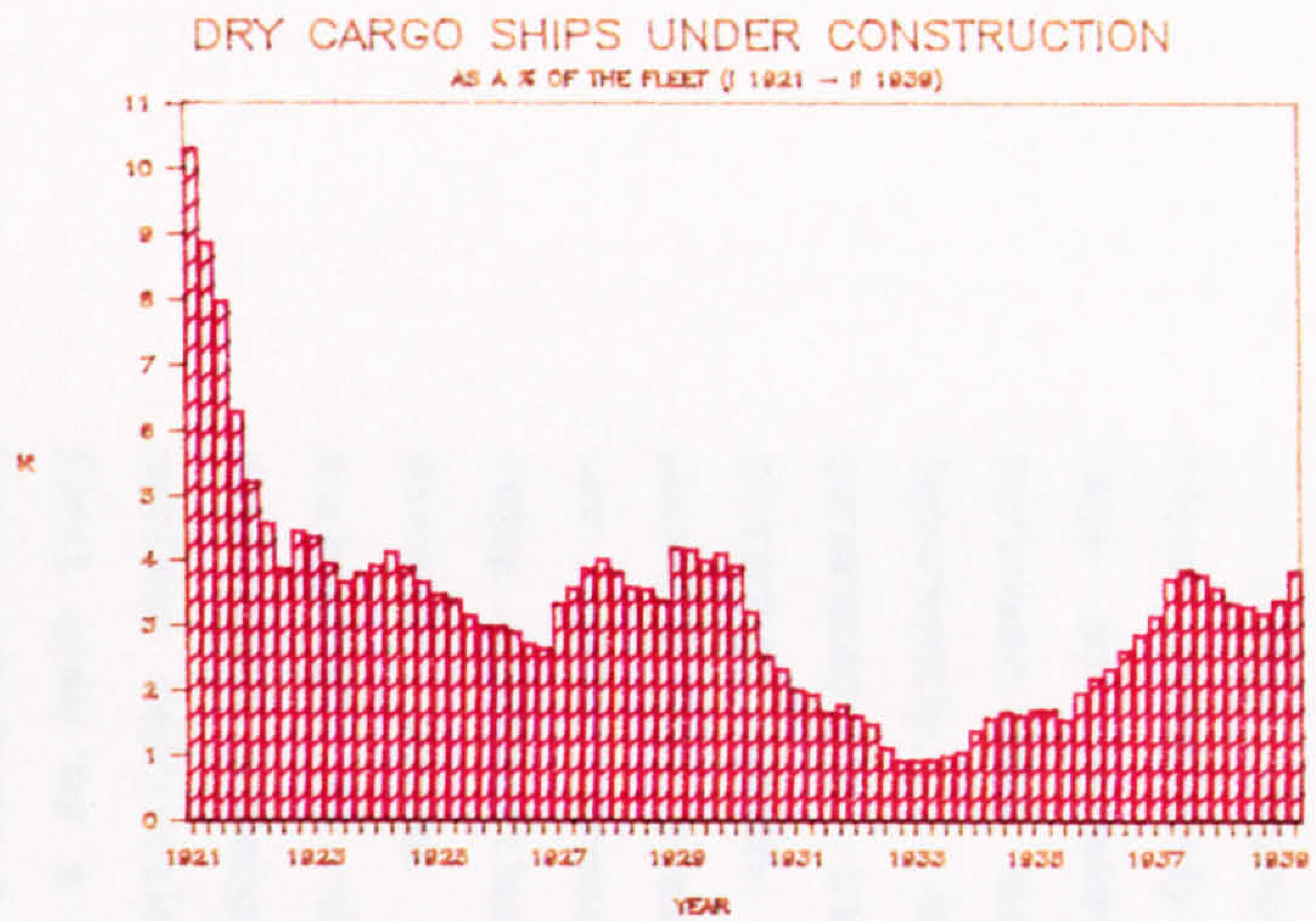


FIG. 1.27

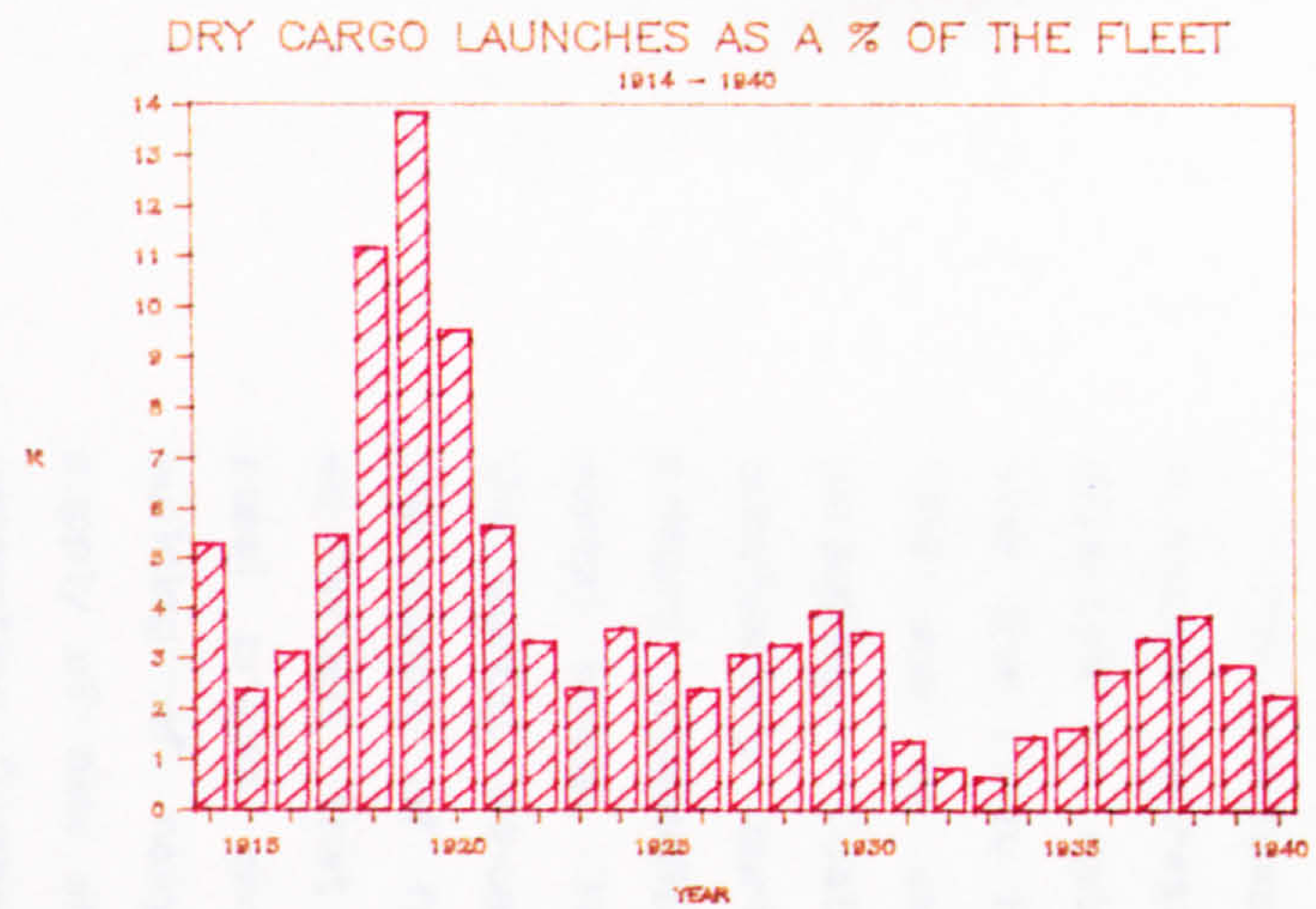


FIG. 1.28

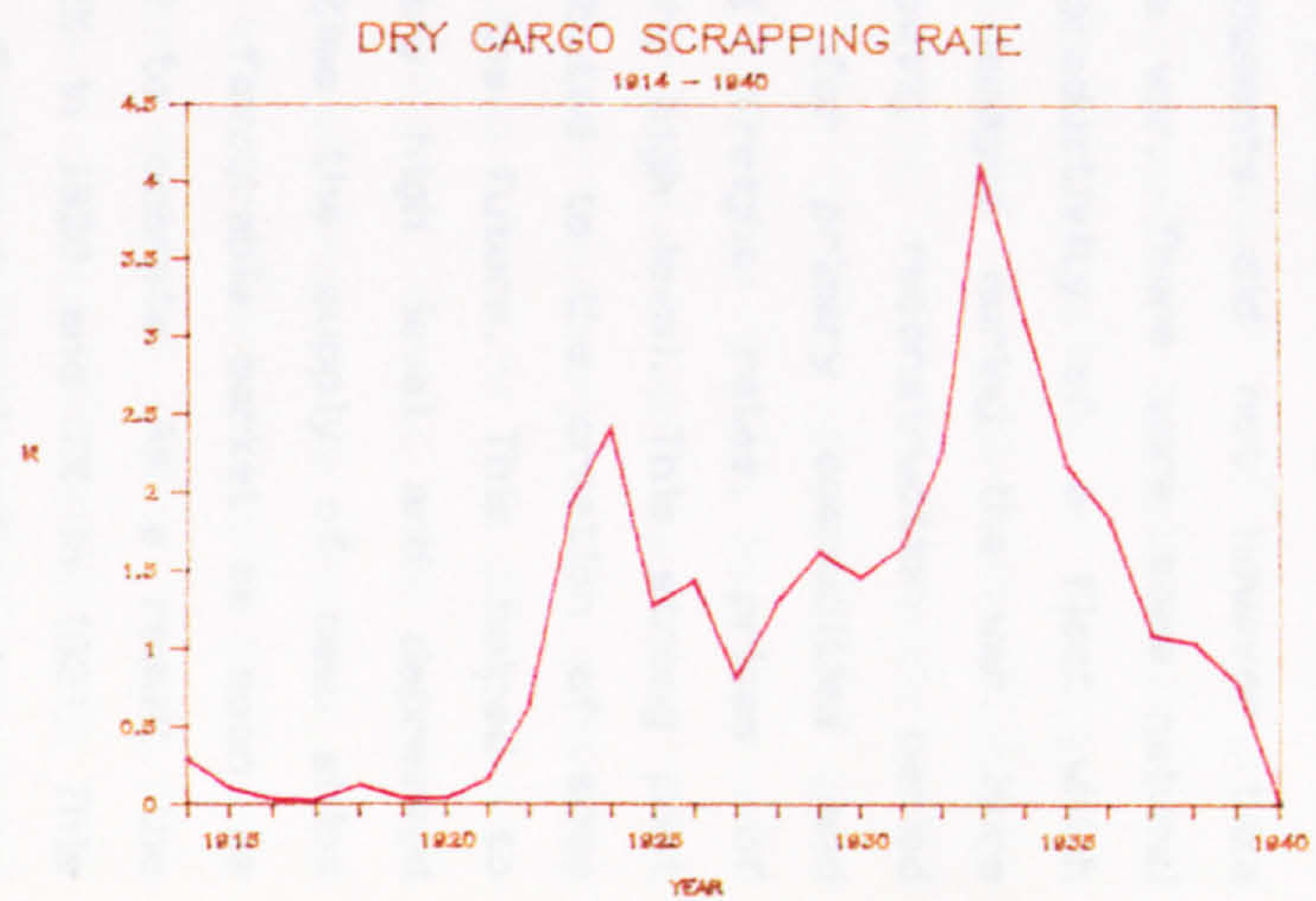


FIG. 1.29

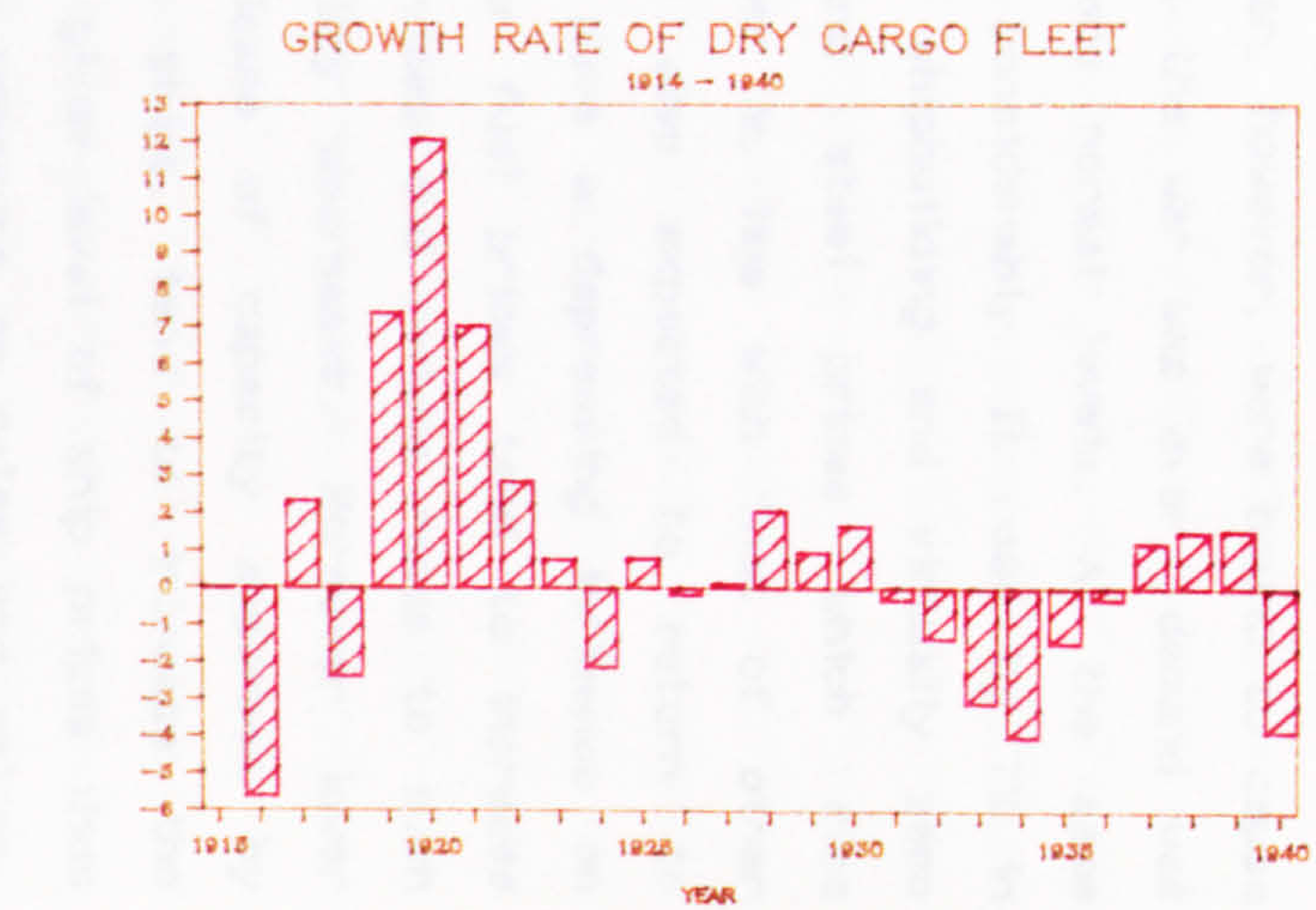


FIG. 1.30

Inflationary expectations also contributed positively towards a rise in values.

The excesses of the war, however, were bound to cause a severe depression. Once the war was over, demand was expected to return to more normal levels. At the same time the fleet had grown considerably. It rose by 7% in 1919 due to war related shipbuilding and virtually zero scrapping. Coal, oil and steel prices which rise considerably during the war in line with that of other primary commodities, were also expected to return to normal levels. This would have a depressing influence on the market since the lower fuel prices tend to increase the supply of freight services and reduce rates to such an extent that profitability decreases. Moreover lower steel prices and the release of capacity absorbed by building of navy fighting ships, tend to increase the supply of new ships at a given level of ship prices thus generating further downward pressure on rates and values. The productivity of the fleet was also expected to increase after the war as ships would be utilized more efficiently in the pursuit of profit.

These expected developments did not however take place immediately after the war. There were some natural lags in increasing the productivity of a fleet which moreover had been badly damaged during the war. More importantly, the following reconstruction period generated a big demand for primary commodities and shipping which maintained freight rates, prices of bunkers and steel at a very high level. This strong post war market probably contributed to the creation of some false optimistism about the future. This helped to maintain prices at a very high level and depressed scrapping. At the same time the supply of new ships responded strongly to the favourable market as soon as wartime restrictions ceased to operate. As a result the fleet grew by a further 12% in 1920 and 7% in 1921. This happened just when demand, fuel and steel prices began to fall while the fleet productivity improved. These unfavourable demand and supply shocks in conjunction with the rapid increase in the size of the fleet caused rates to collapse and lay-up to rise to over 15% in 1922. Time charter rates fell from an average of 23 shillings per dwt per month in the first half of 1920, down to 3.5 shillings by 1923. In the next 7 years they oscillated around that level. At the same time prices also dropped catastrophically as there was no way that the huge surplus could be eliminated for some years without a big drop in prices that would increase scrapping and deter shipbuilding. The value of a 10 year old 5000 dwt steamer dropped down to £24000 in 1922 against £88000 in 1921 and £164000 in 1919. The real yield on alternative investments rose while inflationary expectations also came down. This also contributed towards a drop in values.

Following the depression in the freight and second hand markets, the shipbuilding industry also became depressed while the volume of scrapping expanded considerably as can be seen from Fig. 1.27, 1.28 and 1.29.

Subsequent developments in external factors were also unfavourable for the market. Bunker and steel prices remained depressed. The mild growth in demand during 1923 and 1924 only contributed to a reduction in surplus but had no effect on rates and values. To make matters worse, demand fell significantly in 1925. There were some minor bright spots in the years 1927 to 1929 when demand grew strongly and prices rose by 50% from trough to peak while time charter rates briefly reached 6 shillings per ton. Shipbuilding also showed a minor recovery while scrapping dropped. Then came the biggest shock of the period which was of course the huge drop in demand that occurred during the Great Depression of the early thirties. The depression was to a great extent caused by the trade war policies of the industrialized countries. This meant that the shipping industry was disproportionately hit as demand for transportation services fell by a staggering 30% within a space of 2 years, causing the already depressed rates to drop further. Time charter rates fell to a level just over 2 shillings per ton and did not increase throughout 1931 to 1935. Lay-up increased to over 20%. Shipbuilding volume dwindled to less than 1% of the fleet while scrapping rose to over 4% causing a reduction in the size of the fleet. The price of our representative cargo steamer dropped down to £6800 in 1932 against £30300 in 1929 as profits became negative and the real return to capital rose. In real terms ship prices reached their lowest level of the whole period of the last 120 years. Shipbuilding as a percent of the fleet also hit all time lows while lay-up reached an all time high. The high level of scrapping of this period was only surpassed during the recent depression of the 1980s. The fleet kept falling for a record period of 6 consecutive years. This contributed to a gradual improvement in the freight market balance and a reduction in lay-up. The depression ended in 1937 when demand grew strongly and time charter rates soared to 9 shillings per dwt per month. Values, after rising gradually throughout the depression from £6800 in 1932 to £18500 in 1935 and £26400 in 1936, jumped up to £56400 in 1937. The following year demand fell again and some pessimism returned to the market. Time charter rates fell to 3 shillings per ton and values dropped to £30200. Then came the outbreak of the second world war which send rates and prices skyrocketing again. Time charter rates rose to $4 dollars per month and the value of the representative steamer reached £75300 in 1939, £92000 in 1940 and £181200 in 1941.

1.2.4 The post war dry cargo market

Unlike the 1920's and 1930's, the post war II market did not experience a major depression for a long time. There were also structural changes during this post war period, as the tanker sector grew at an average rate of 13% p.a and in terms of both ton-mile and fleet figures it became larger than the dry cargo market. The implication for our analysis is that the dry cargo market became now sensitive to events which can be considered as having a direct impact only on the tanker sector. Because of freight, shipbuilding and scrap market linkages between the two sectors, these events would eventually have repercussions on the dry market as well. Thus a rapidly growing demand for tankers would now absorb a significant amount of shipbuilding capacity thereby restraining the growth rate of the dry cargo fleet. In the demolition market, it would lead to a withdrawal of tankers for scrap, the demand for which would then tend to be satisfied by increased dry cargo supply. This would further restrain the growth rate of the dry cargo fleet.

On the freight market side, the rapid growth of the combi fleet during the 1960s and 1970s implied that fluctuations in the tanker market would immediately affect the dry sector as these versatile ships would switch from one market to the other in search of better profits. During the fifties, when combis were very few, the link between the two freight markets was weaker, based as it was on the limited capability of some tankers switching to the grain trades. Before World War II such linkages already existed between the two markets, but the small size of the tanker sector prevented it from having a significant impact on the major dry sector. Now that it had come of age, its fluctuations would quickly reverberate onto the dry cargo markets. Certainly external shocks are felt more strongly by the sector which is directly affected, while their effect tends to dissipate as it spreads to other sectors. However, because external factors affecting the tanker industry are more unstable than those affecting the dry cargo sector, this can make them as important in generating oscillations in the dry market as the latter.

Demand for dry cargo shipments grew rapidly in the fifties and this absorbed a significant amount of the total capacity created during the war. The underlying economic/political environment contributed strongly to a rise in trade and demand for shipments. Europe run out of

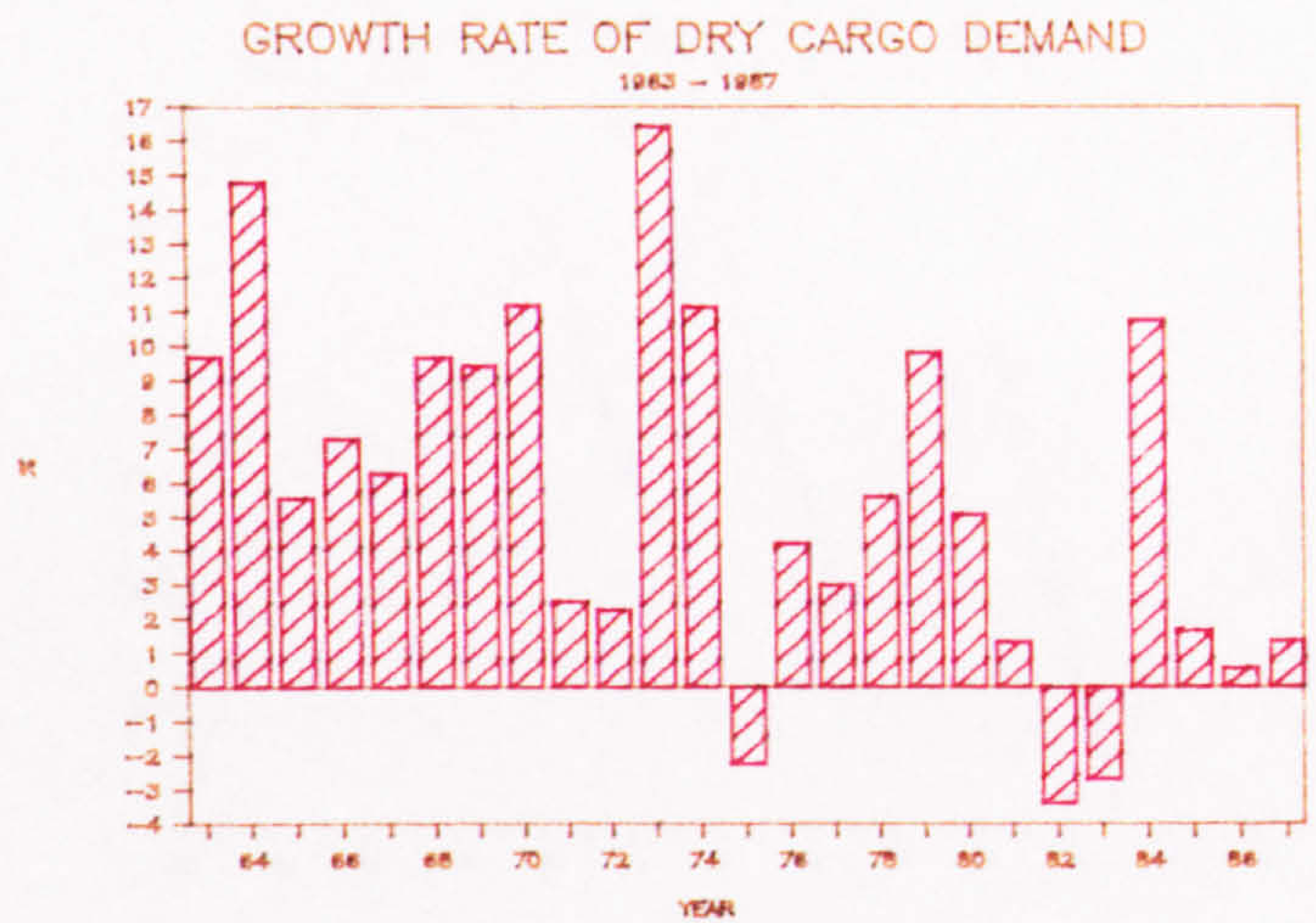


FIG. 1.31

FIG. 1.32

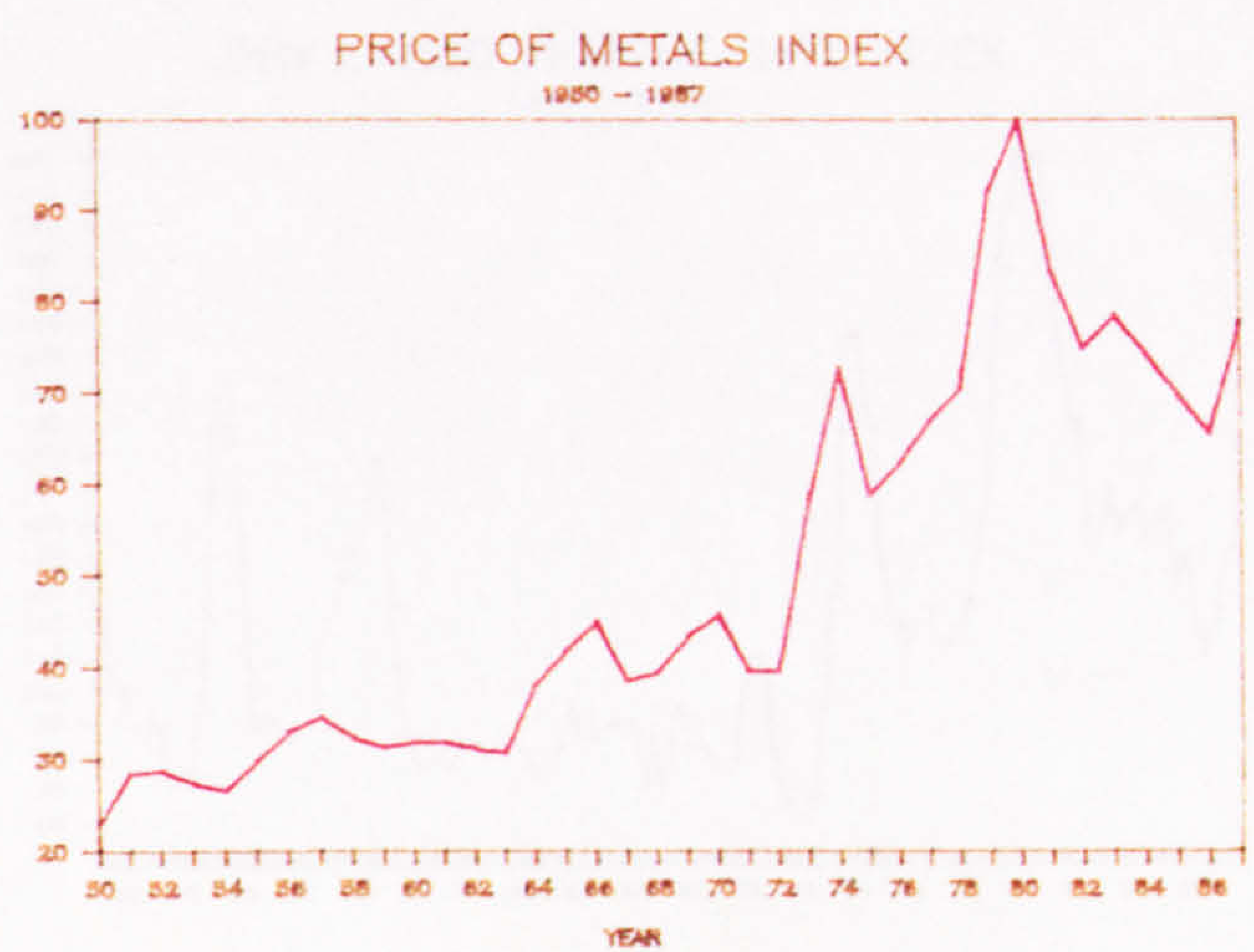
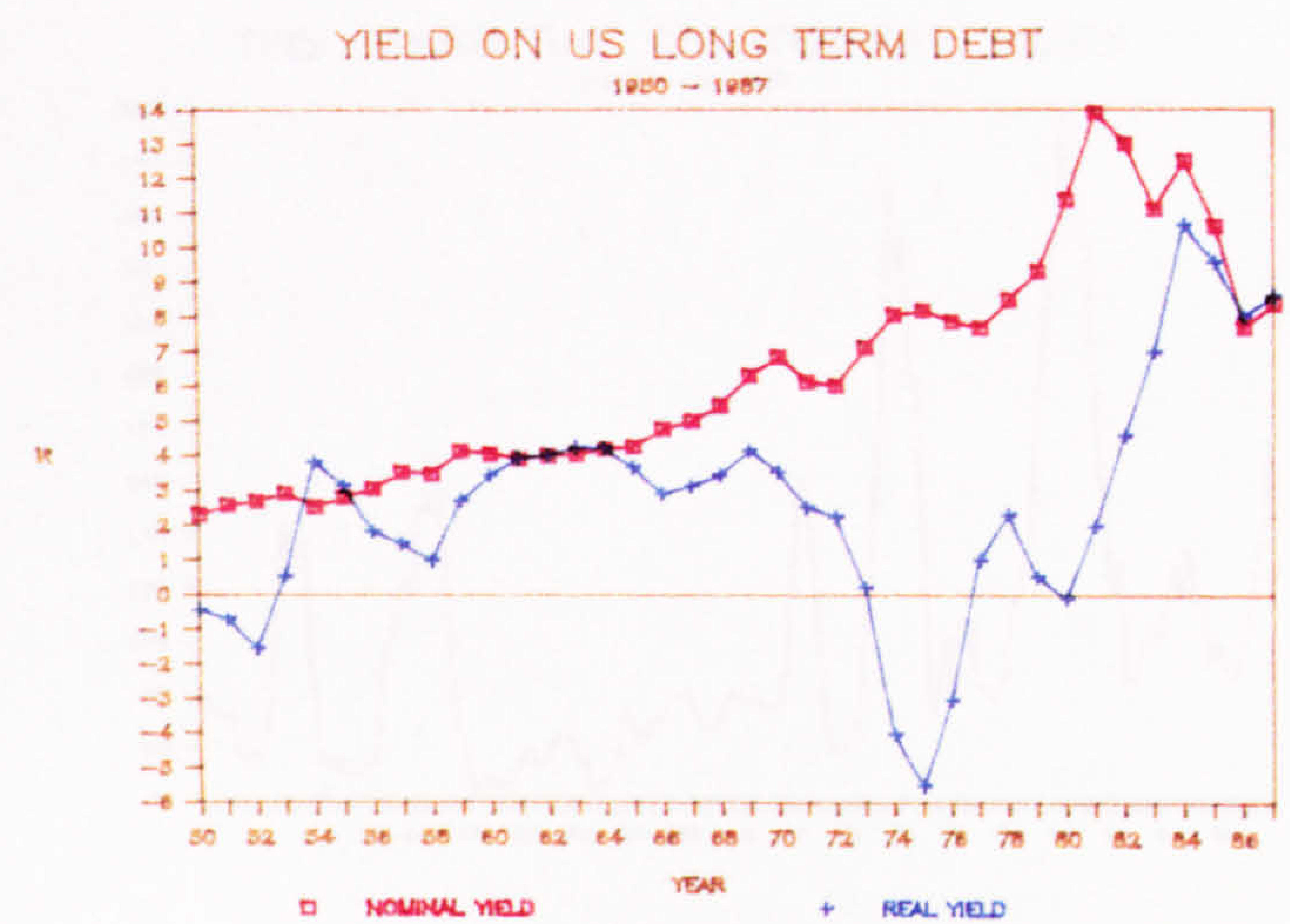


FIG. 1.33



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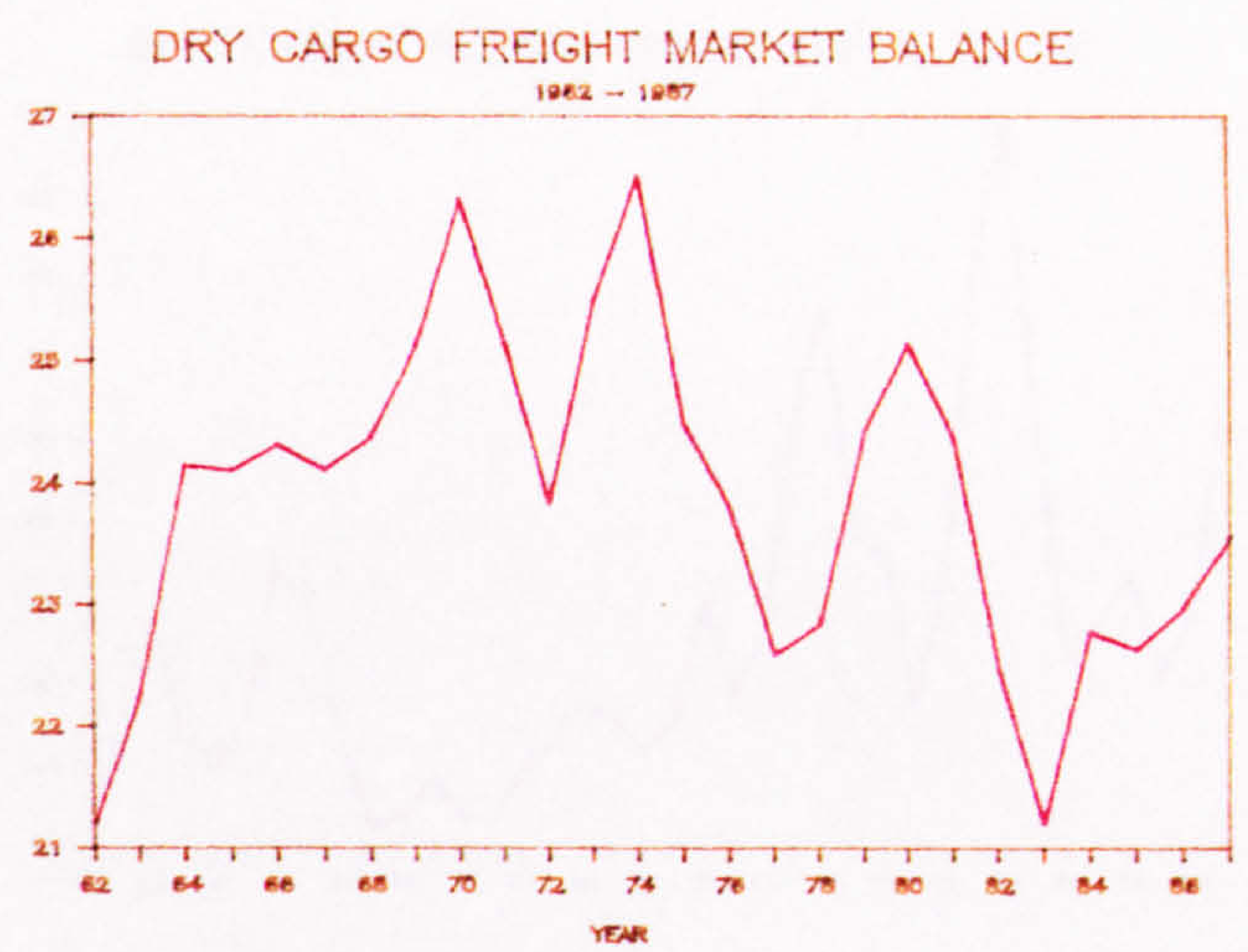


FIG. 1.35

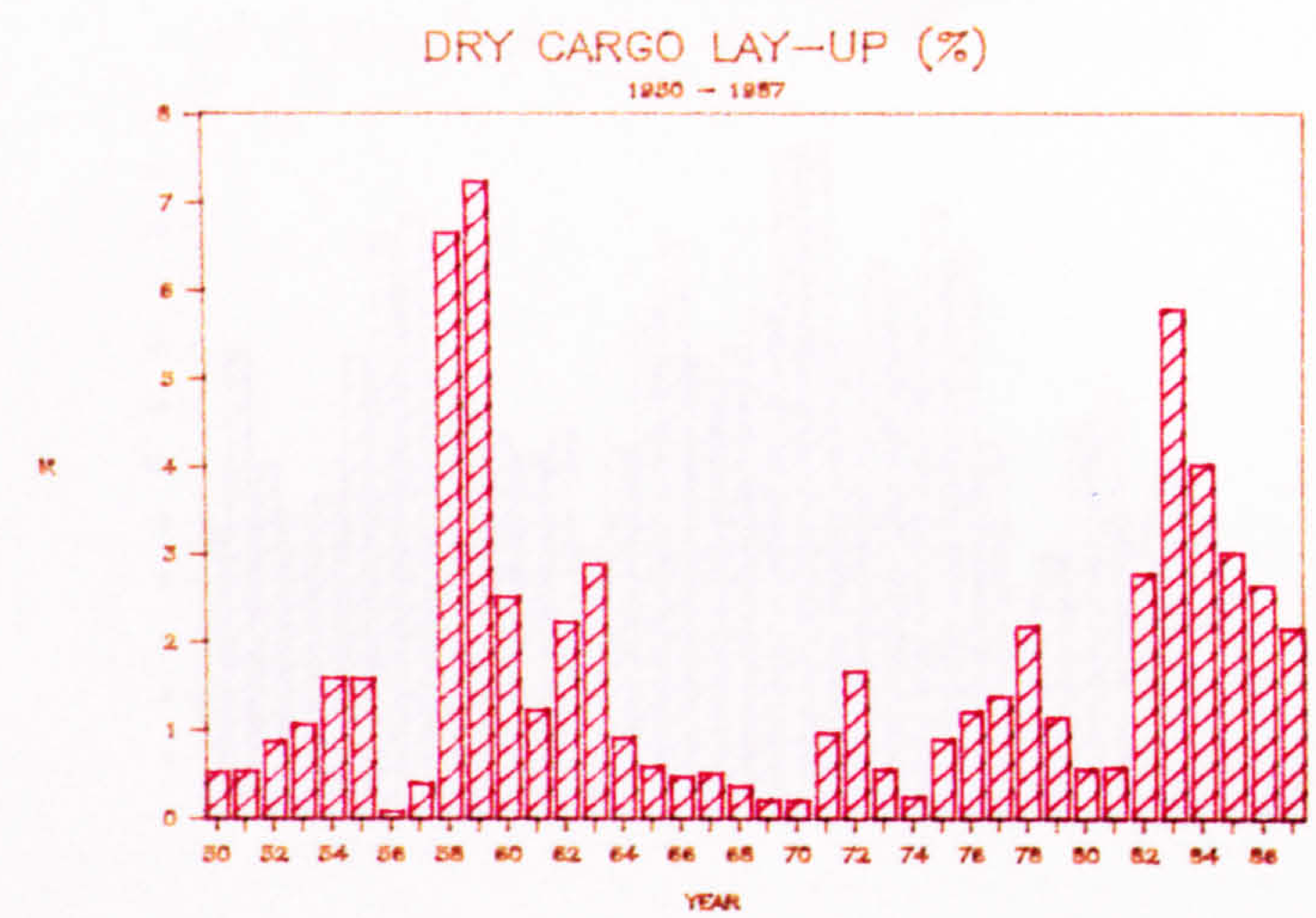
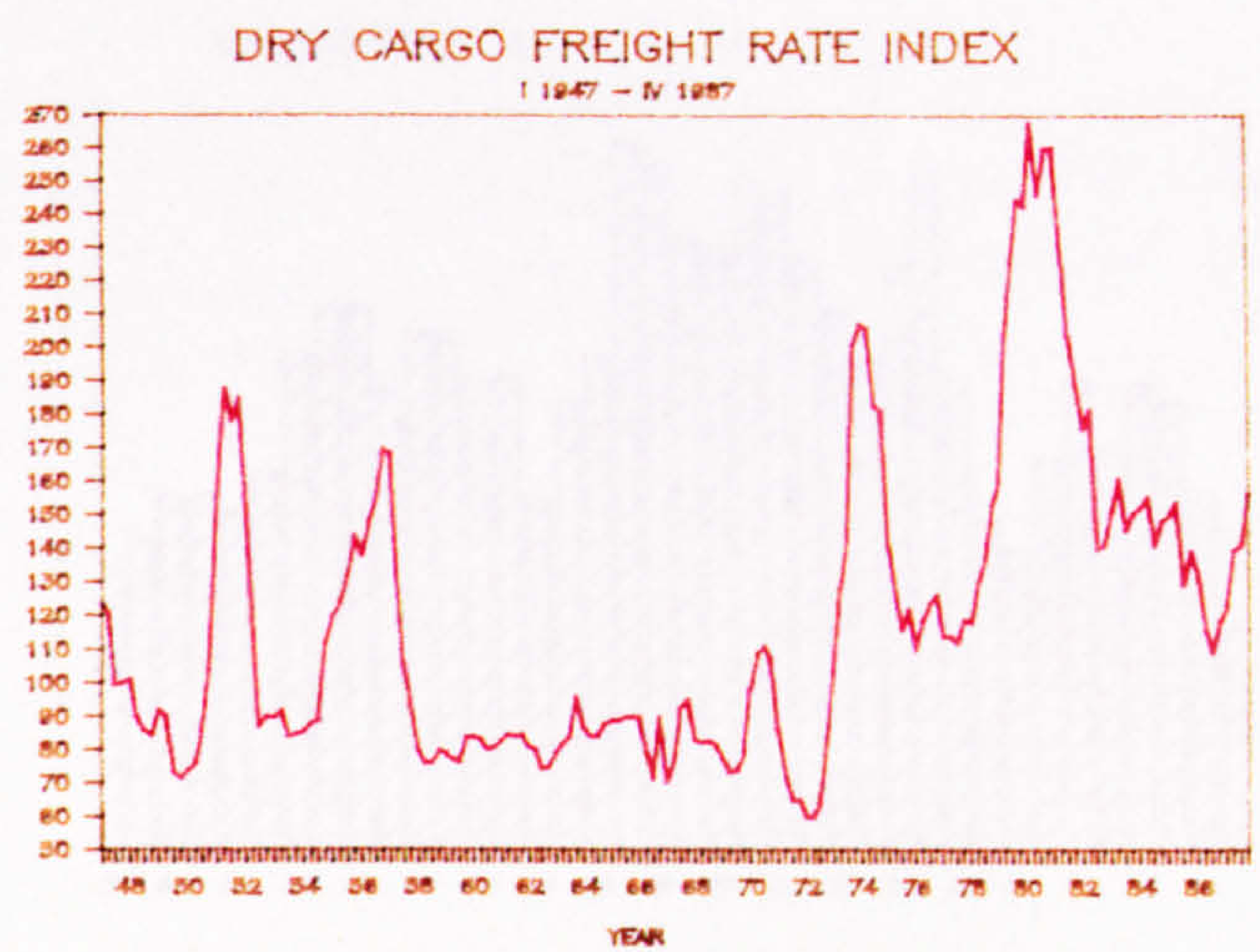


FIG. 1.36



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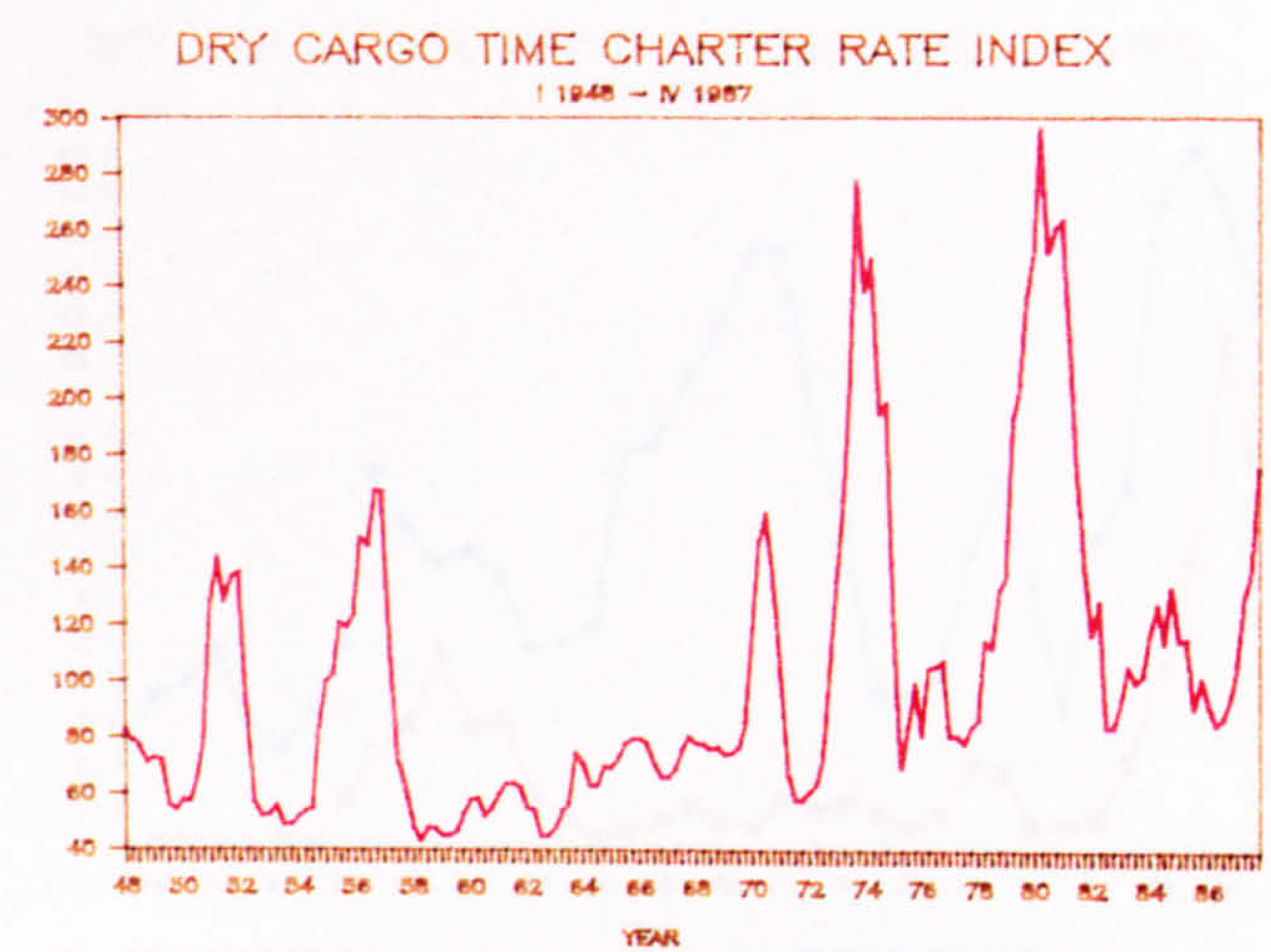

FIG. 1.38

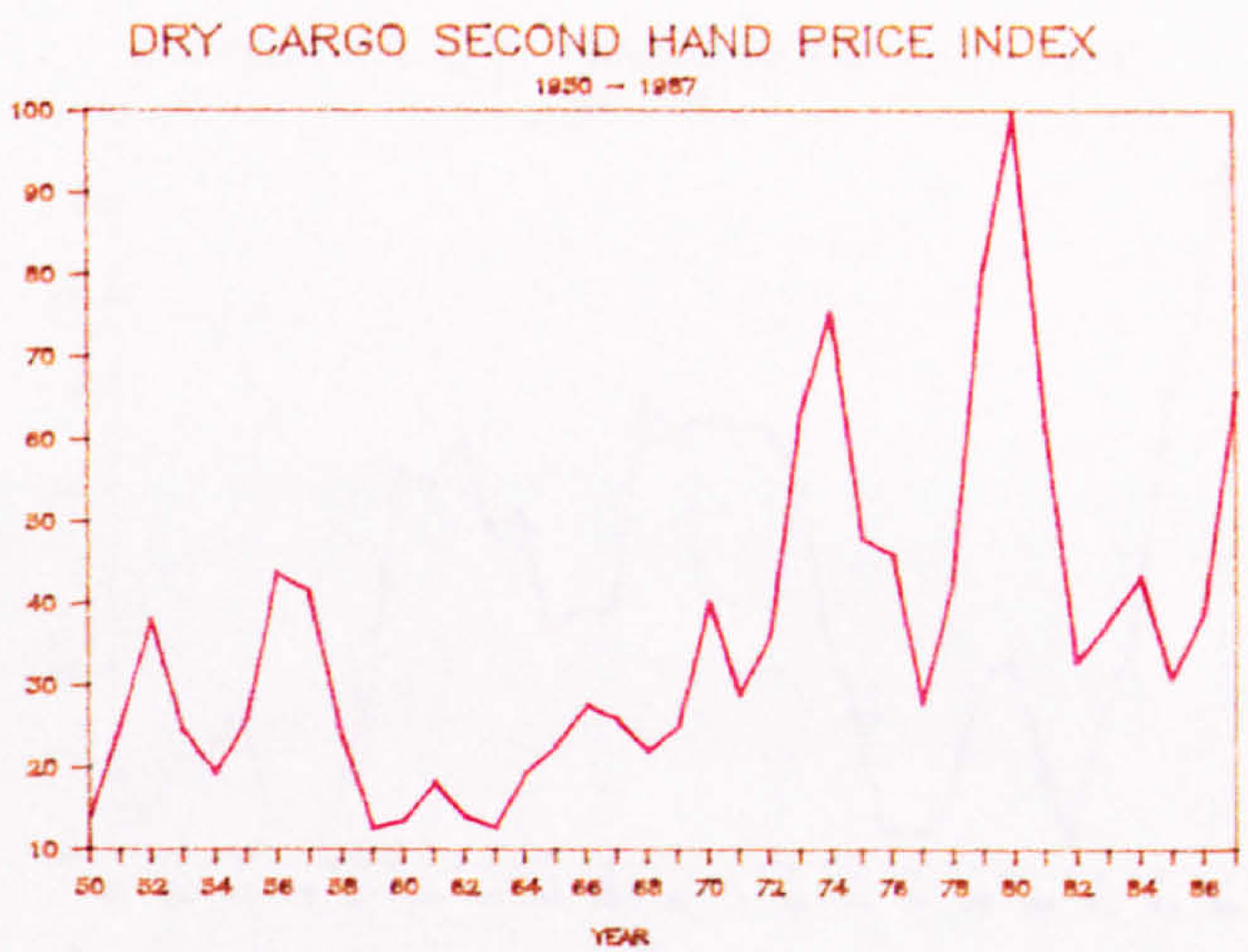

FIG. 1.39

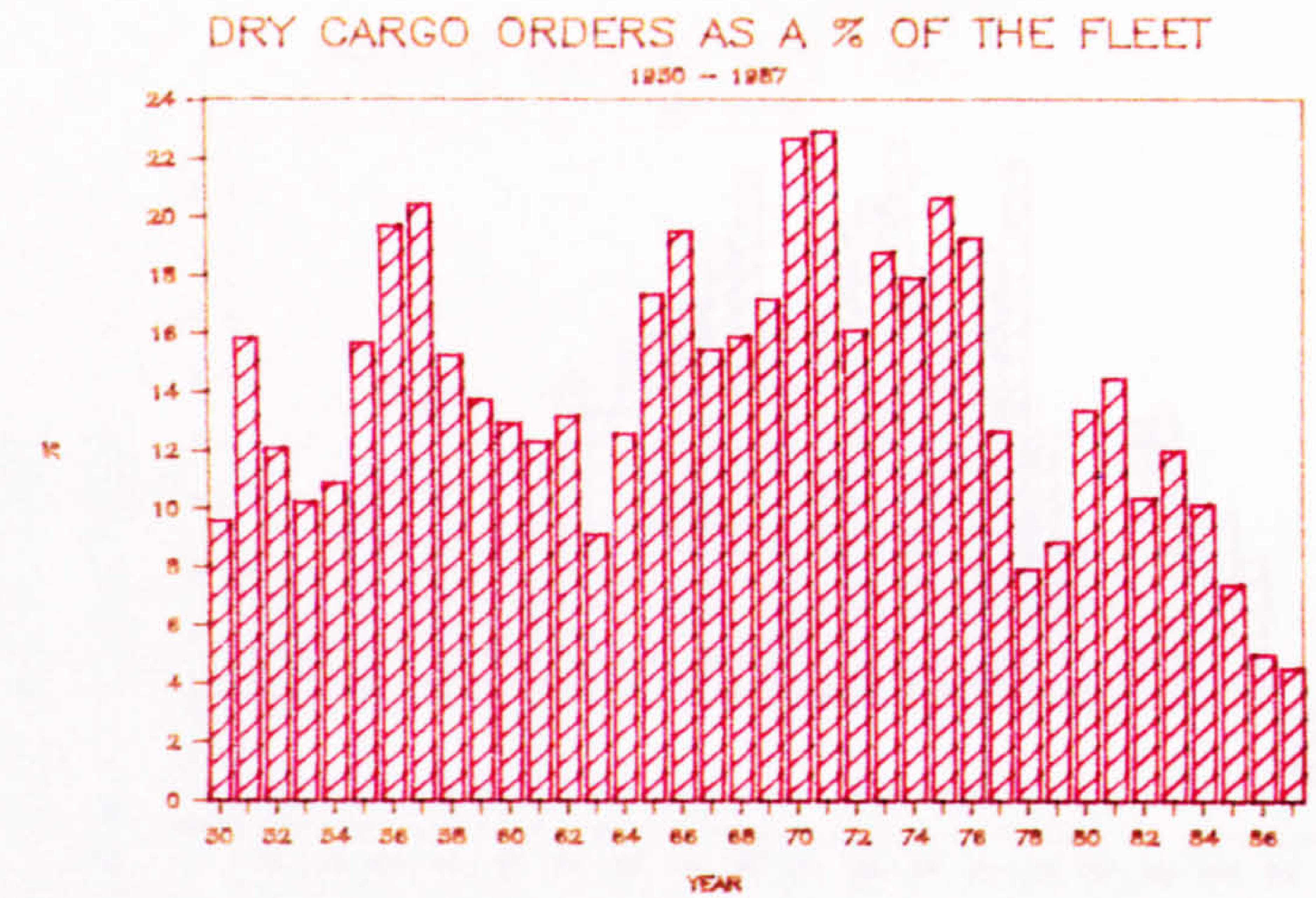

FIG. 1.40

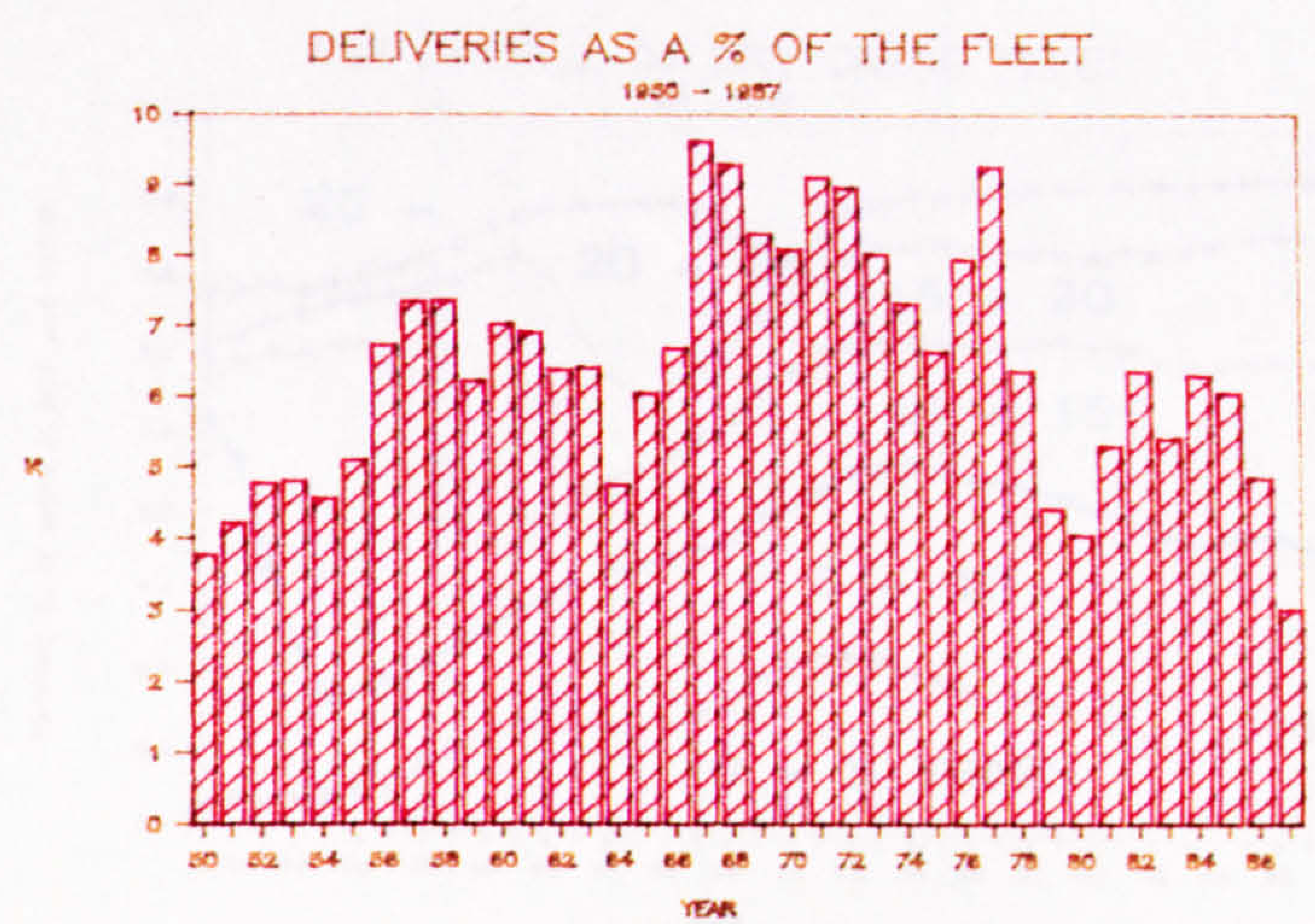

FIG. 1.41

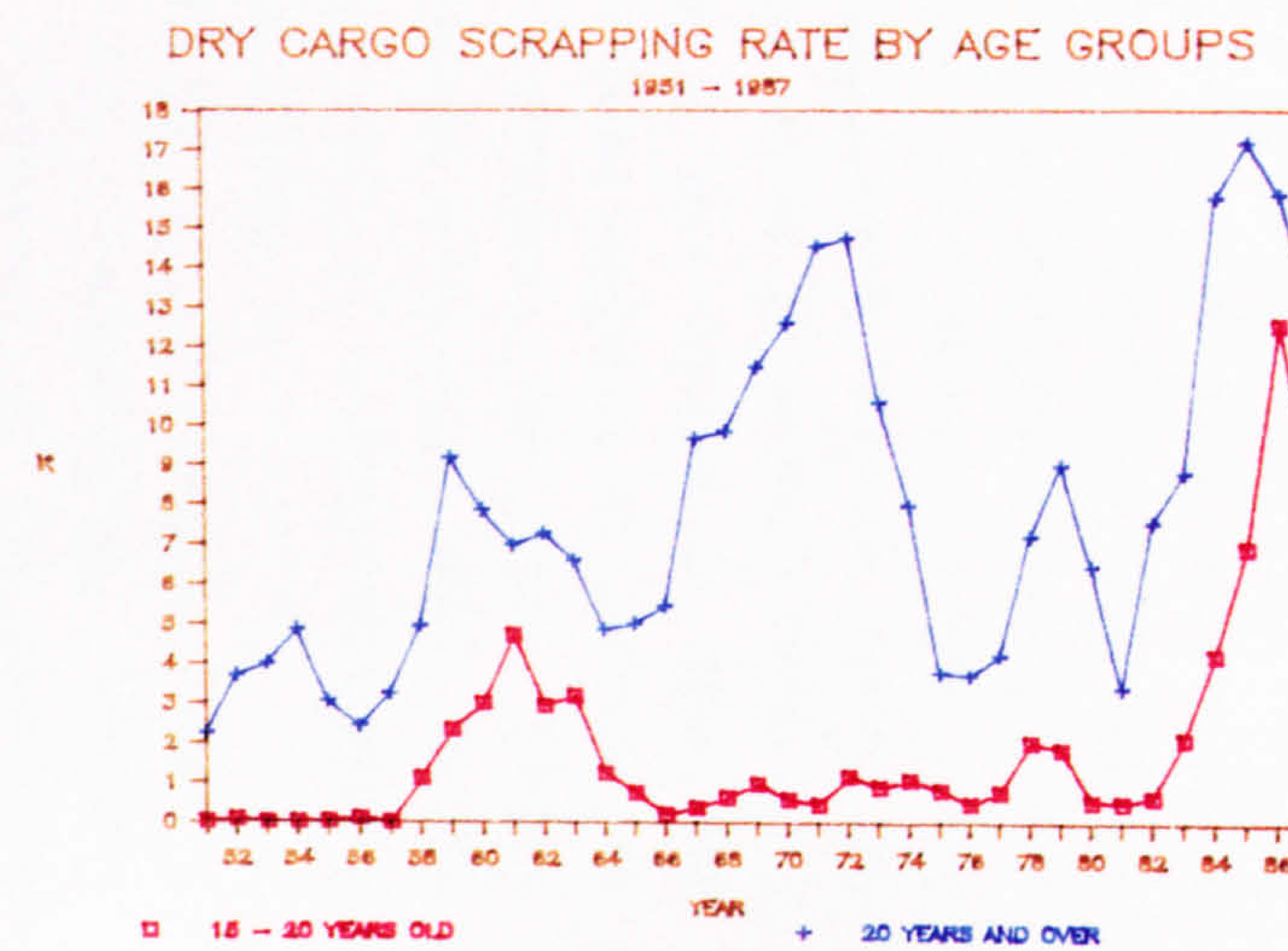

FIG. 1.42

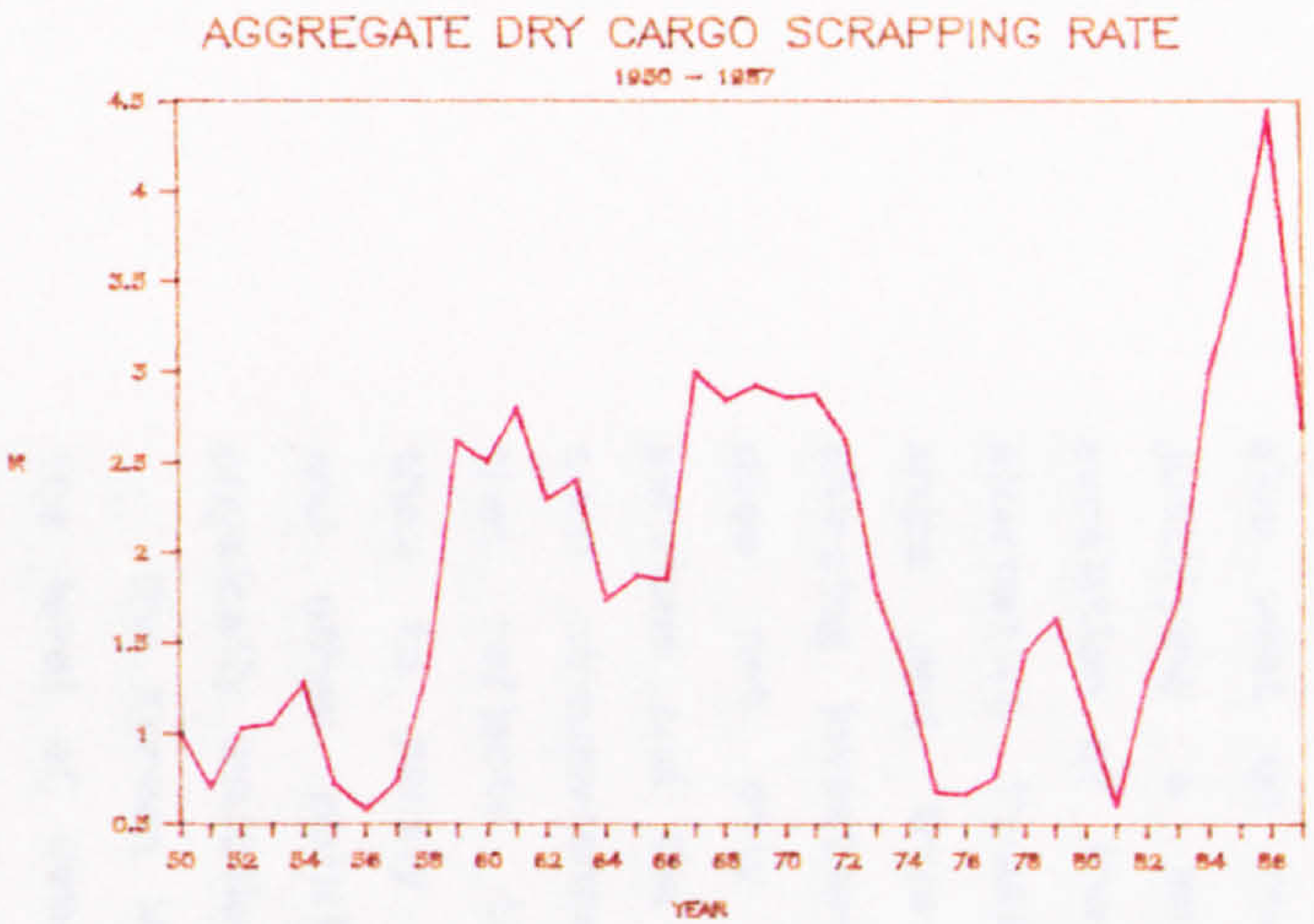

FIG. 1.43

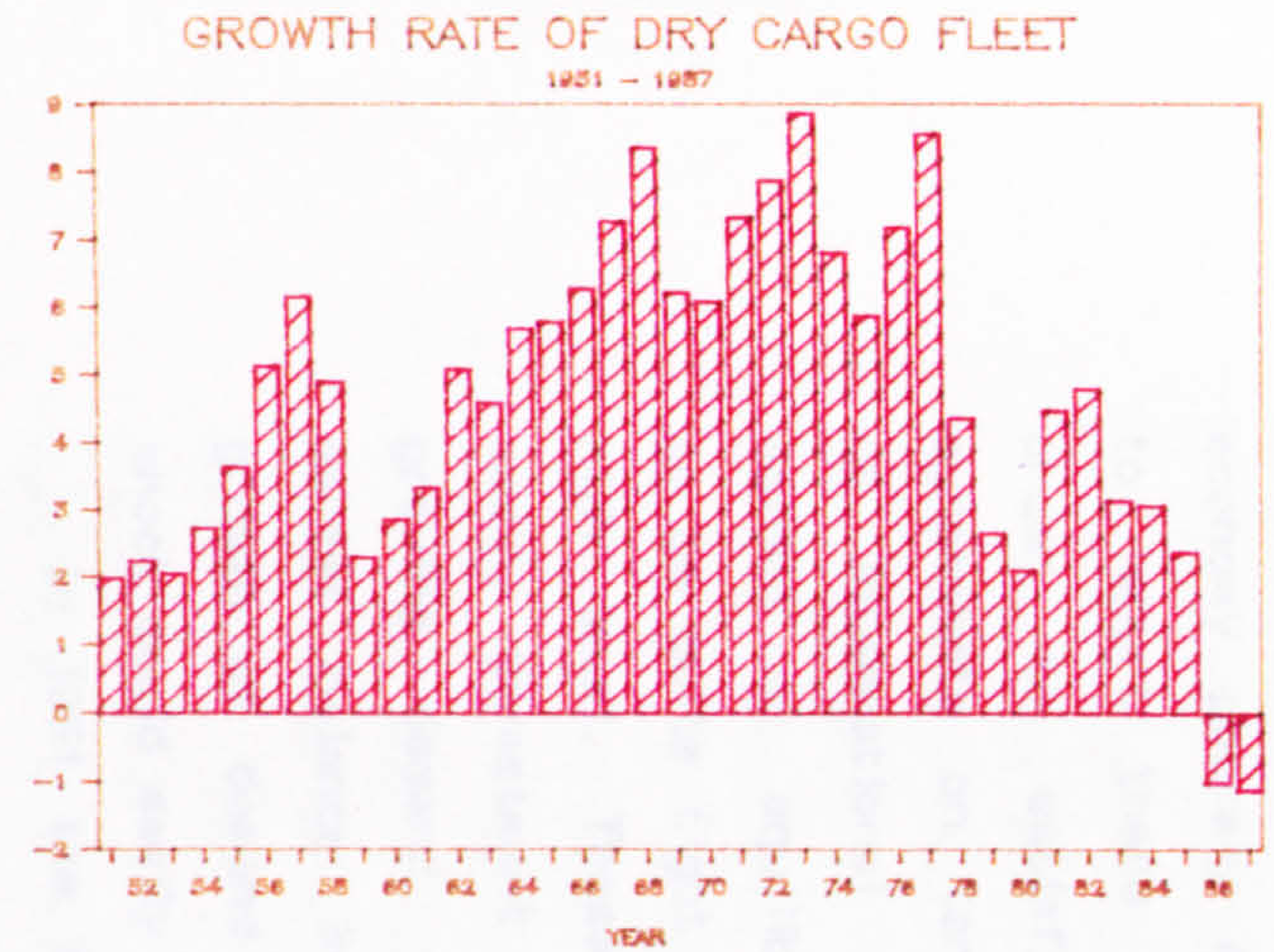

FIG. 1.44

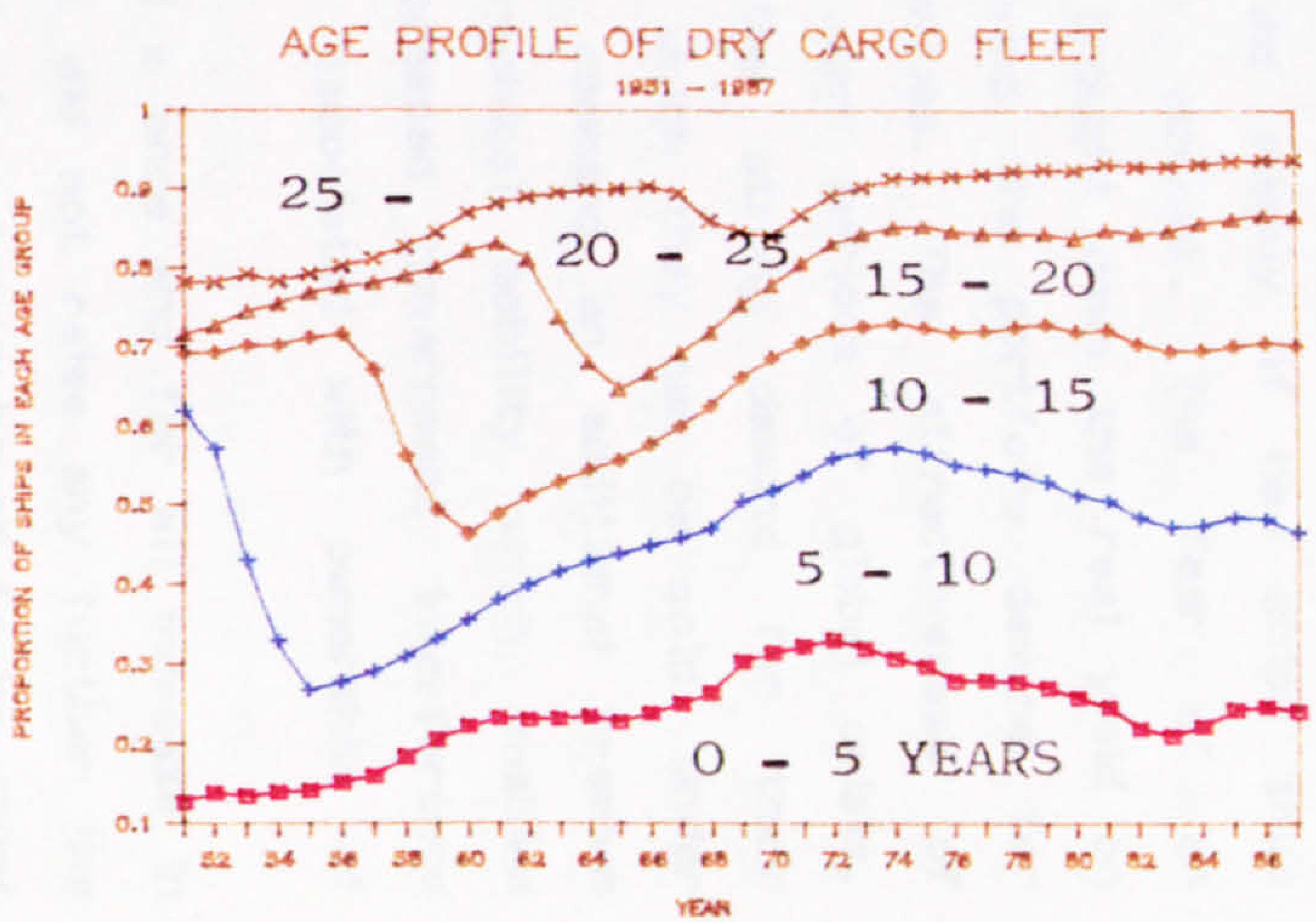

FIG. 1.45

domestic coal and iron ore and had to import from distant areas. The Japanese economy grew rapidly. Being an island economy poorely endowed with primary materials, she had to import these goods by sea over long distances, in order to satisfy its hungry industry. The general agreements on tariffs and trade encouraged an expansion of international transactions. The strong growth rates implied an equilibrium freight market balance which had to be quite tight on average so as to maintain rates at a high level. These high rates were needed so that the costly investment on newbuildings required to satisfy the growing demand could be recouped. The tight freight market balance in turn implied that any spurt in the growth of demand above its trend or a favourable supply shock could easily send rates soaring.

In 1951 the Korean War led to a stockpiling boom of strategic reserves in the industrialized countries generating big demand for shipments. At the same time bunker prices increased by over 60%. This restrained the supply and created further upward pressure on rates. Indeed rates and values more than doubled. Metal prices also went up restraining the supply of new ships thus justifying a more bullish outlook. The fear of an escalation of the conflict brought down the real yield on alternative investments raising the portfolio demand for ships and thus their values. The attractiveness of shipping investment during such periods of global crisis, does not only reflect the strong demand for their services and the rates at which they can be sold. Under such circumstances, ships command an additional premium that reflects their geographical mobility which enables them to partly avoid increased government interference and other political risks associated with ownership of physically immobile assets.

The Korean War created a once and for all increase in the level of demand but it did not raise any further the long run growth rate, so its impact was bound to be short term. Moreover there was a one to one direct trade off between the then current level of demand for shipments and future level of demand. Following a stockpiling boom, future industrial demand for primary goods is satisfied by running down accumulated stocks rather than by new production and imports.

The firm ship prices of the early 1950s, supported by strong underlying long term growth of demand and also by the psychological boost of a booming freight market led to an expansion in the supply of newbuildings. The reduction in scrapping that took place during the boom put an additional future burden on the market. Once the crisis and the associated stockpiling was over, demand fell. On the supply side the fleet expanded and bunker prices fell pushing rates further down to a third in comparison with their previous peak. Values followed a similar trend dropping by more than 90% which was a lot less than the drop in profitability at a time when real returns to capital were rising. This partly indicates that the market - correctly as it proved - retained some optimism for the future. The growth rate of the fleet did not register any significant drop and thus lay-up increased as growth in demand temporarily lagged behind growth in capacity.

World economic growth recovered strongly during 1955 and 1956 and with it the demand for shipping. Rates rose considerably and lay-up fell. In October 1956 came the first closure of the Suez Canal which caused time charter rates to rise above their Korean War peak and lay-up to fall to zero in the beginning of 1957. Metal and fuel prices rose again. The real return to capital fell. There was a risk of the canal remaining closed for a considerable amount of time and this helped to raise prices by 115% from trough to peak and to expand the order book considerably.

The high average profitability of the period 1950 - 1957 should to a large extent be attributed to the high growth rates in the demand for shipments that were experienced during that time. The firm growth rate in the tanker market was also another contributing factor. Demand for tanker shipments was rising at annual rate of

10.6% p.a. over this 7 year period and had to be satisfied by an annual output of new tankers which averaged out at about 3.5 million dwt per year whereas that of dry cargo amounted to slightly higher amount of 3.7 million dwt per year. This indicates that already by that time the tanker industry was absorbing a significant proportion of the available shipbuilding capacity thereby restraining the growth rate of the dry cargo fleet. In order to estimate more accurately the proportion of the shipyard capacity absorbed by tanker relative to dry cargo construction allowance should be made for the fact that one ton of a representative new tanker built during that period absorbed a much lower amount of shipyard resources than a ton of a new dry cargo ship. To a large extent this was due to the fact that the average size of a tanker newbuilding was much larger than that of a dry cargo one. Typically, the construction of a large ship requires a smaller amount of shipbuilding resources - as measured say in compensated gross registered tons (cgrt) terms - per ton. Taking a 30000 dwt tanker and a 10000 dwt dry cargo ship as representative newbuildings we find from conversion factor tables that the former required only 0.4 cgrt per ton while the latter required about 1 cgrt per ton to be build. This implies that the proportion of the active capacity absorbed by tanker construction was as much as 27% during that time.

In March 1957 the canal reopened reducing the mile factor in the demand for ton-miles. Moreover world economic growth also fell at round about the same time thus reducing the volume of shipments as well. Suddenly most of the ships that had been ordered during the boom were not needed. These developments caused quite a severe depression which lasted for 6 years. Newbuildings delivered during 1958 and 1959 together constituted 15% of the existing fleet. This extra capacity was being delivered at a time when growth in demand had slowed down considerably causing lay up to rise to over 7%. The depression also saw prices fall by 70% and rates by 75% from peak to trough. Scrapping rose to over 2.5%.

The low rates could not allow a return to be earned on a newbuilding even if it had been bought at cost. The growth rate of the fleet was thus subsequently restrained and with demand growing strongly during the early 1960's the market begun to recover in 1963. Prices soon doubled admittedly rising from a very low level. Prices and rates continued to recover throughout the sixties. As can be seen from Fig. 1.31 the growth rate in demand was strong during these years. This was especially so in 1963 and 1964 and as Fig. 1.35 indicates it contributed to a significant improvement in the freight market balance. Most of the laid up ships (Fig. 1.36) were absorbed by this increase. The market benefited from the second closure of the Suez Canal in the summer of 1967 but in spite of these favourable shocks and the strong underlying long term growth in demand the market failed to boom properly until 1970.

One reason for that was technological innovations on the shipbuilding side which led to the development of the bulk carrier. This was a single deck, large vessel designed to carry dry bulk goods. The economies of scale associated with the operation and building of larger vessels allowed it to earn a better return on its building cost than conventional cargo ships. Thus the low rates which had previously prohibited the building of conventional cargo ships could now encourage the building of bulkers at prices which would allow both the investor to recoup his capital and the shipbuilder to make a profit boosting both the demand and the supply of these newbuildings. Thus the growth rate of the fleet could be maintained at a rate which roughly equalled that of demand without a big increase in rates and prices being required.

But for this development of new ship types in both the dry cargo and tanker sectors the markets would have boomed much earlier as the average freight rates of the sixties could not justify the construction of the older ship types in large quantities. The sixties are a classic case of the technological development of a new, efficient and cheap to build capital good, leading to an increase in investment and a parallel dampening effect on rates. Of course rates did not actually fall because the negative effects of the innovation were more than cancelled out by the strong growth rate in demand and the fact that initially the market was at a very low level and, finally, because of other factors operating through the supply side.

By the end of the sixties the market had become very tight and lay up was at a very low level. This implied that any spurt in demand above trend could cause a considerable increase in rates. It was statistically inevitable that under such a situation of high growth and tight market balance, there would have been some years when additional growth would sent rates up. This occurred in 1970 when demand grew at around 11%, a six year record. Time charter rates doubled, while prices increased 75%. There were also positive developments taking place on the supply side. The booming tanker market had absorbed most of the combined carriers. The proportion of over-aged ships (Fig. 1.45) had increased significantly reflecting the abnormal shipbuilding output of World War II. The scrapping rate (Fig. 1.43) therefore persistently exceeded 2.8% during the late sixties and early seventies regardless of market conditions putting extra pressure on rates and prices. On the shipbuilding side, metal costs (Fig. 1.33) had been on an upward trend ever since 1963 further restraining the growth of the fleet by hitting shipbuilding and increasing the demand for scrap. The tanker market was growing during the sixties by a compound average rate of 13.3% p.a absorbing 32% of the active shipbuilding capacity.

In 1971 and 1972 the growth of demand fell to something over 2% against a compound average of 9.2% over the previous 8 years. At the same time the fleet was growing at a rate of over 7% p.a. Thus lay up rose significantly almost reaching the 2% mark. Freight rates fell considerably but prices only to a smaller extent. Bunker prices had begun to rise gradually since 1969 and this was exerting a mild upward pressure on rates which finally boomed again as the growth rate of demand reached a 10 year record level of over 16% in 1973. Most of the laid up ships were absorbed and rates soon doubled. The tanker freight market was also booming more strongly absorbing most of the combined carriers.

The optimism regarding future growth in tanker demand generated by falling US oil production and rising imports sent prices up, and the tanker order book expanded to a level which constituted 90% of the existing tanker fleet. As can be seen from Fig. 1.41 dry cargo deliveries as a percentage of the fleet had 'paradoxically' been on a downward trend ever since the closure of the Suez Canal in 1967 and this trend continued up to 1975, in spite of the strong market. The flow of causation was actually the opposite which explains the paradox of a strong market and falling delivery rates. Various factors where restraining the growth rate of the dry cargo fleet thereby contributing to the increase in rates and values. The strong tanker market was absorbing an increasing share of shipbuilding capacity thereby restraining the delivery rate of dry cargo ships (Fig. 1.41) and causing the dry market to rise further. In addition it was very difficult for shipbuilding capacity to expand rapidly. We estimate that between 1971 and 1976 and in cgrt terms, tanker construction absorbed a record 52% of actual shipbuilding capacity. In 1974 the solid 11.1% growth in demand and the phenomenal increase in bunker prices (Fig. 1.32) to something like $80 per ton caused the already booming time charter rates to reach a new post war peak which exceeded the previous best by around 55%. Prices also moved higher to a new peak which exceeded the 1956 peak by around 65%. Part of this peak to peak increase was inflationary.

It was impossible of course for the market to sustain itself at such a level even if subsequent events had been more favourable and more in line with expectations. The unanticipated increase in oil prices was engineered by means of a restraint in the supply of long haul OPEC production which was up to then generating most of the growth in tanker demand. The implications for the tanker market were catastrophic as the massive orders of 1973 and the stagnation of demand that was followed by a subsequent devastating drop of 50%, guaranteed that the tanker market would remain depressed for more than 10 years. This was true with the exception of a small hiccup in 1980. The dry cargo market also became depressed shortly after. Industrial activity which generates most of the demand for dry cargo shipments was particularly hit by the increase in oil prices. As a result demand in the dry freight market actually fell by 2.3% in 1975 (Fig. 1.31). The increase in oil prices actually had some beneficial effects on the market but these were swamped by the negative effects of the slowdown in growth. By raising fuel prices and restraining supply through the incentive to slow-steam they generated upward pressure on rates. The fleet continued to grow strongly for some time as a result of the initiation of construction programs during the previous good years.

The stagnation of tanker demand was equally important for explaining the 1975 - 1978 dry cargo depression. Some of the tanker orders placed in 1973 were converted to bulk carriers as a result of the collapse in tanker prices. Moreover as the tanker order book was being depleted shipbuilding capacity was released and had to look for alternative employment as there was no way that more worthless tankers could be built at prices that would be acceptable to investors and that would be profitable to their builders. Under such circumstances the capacity tends to be diverted into the relatively better performing sectors until it depresses them as well. The poor performance of the whole shipping industry in the last 10 years is directly related to the stagnation and subsequent drop in tanker demand which left the shipbuilding industry with no other alternative than to build other types even at a loss.

Sudden unanticipated depressions such as those that occurred after the two oil shocks are usually more severe that the ones that can be partly foreseen. Shipyards expand their capacity and employ more labour if the market is expected to be good. These are long term decisions which are difficult to reverse if unexpectedly the market becomes depressed. There are sunk costs in expanding shipyard capacity which cannot be recovered by restraining production. In addition rapid variation in labour employment is costly. Long term labour contracts imply that wages do not count as part of the marginal costs. In the short run, which can be as long as 5 years, ships will be built as long as the variable metal costs are met. All these factors explain why substantial unprofitable production of new ships can persist during a depression. This pushes the equilibrium level of prices and rates downwards and tends to prolong the depression. In addition the political costs of unemployment in shipyard industries and the strategic value of shipbuilding leads to an increase in subsidies during difficult times that reduce the true cost of production and expand supply. This also depresses prices and prolongs the depression, ironically cancelling out most of the intended benefit of the subsidy. These factors and in particular the depression in the tanker market explain why the dry cargo order book increased (Fig 1.40) during the depression years of 1975 and 1976.

Ship prices fell further while inflation raised metal prices and wages in shipbuilding. Metal prices rose not only in nominal terms but also in real terms. These factors eventually restrained the growth rate of the fleet by immediately increasing scrapping and creating the incentive to cutback the unprofitable production of new ships at least in the long term. The growth rate of the fleet fell to around 2.5% in 1979 and 2% in 1980. By that time demand had picked up strongly growing at a compound average rate of 5.5% between 1975 and 1980.

Between 1978 and 1980 demand was growing faster than the fleet absorbing a significant amount of surplus. In 1979 fuel prices which were already at a high level rose again and this in combination with the tightening freight market caused rates to increase again and triggered a new cycle. New ships were needed to satisfy the expected growth in demand. The actual increase in oil prices created the expectation of a substantial growth in coal shipments to replace expensive oil. Values rose to a new post war high and the order book expanded. Time charter rates more than trebled.

The expectations did not materialize however as the growth rate of demand over the period 1980 to 1987 averaged out at a very low level of 1.5% p.a. Demand dropped for two consecutive years in 1982 and 1983. This drop being unanticipated, it did not lead to any speculative adjustments in the fleet that could have cushioned its negative effects. On the contrary the expectations about the growth rate of demand were running high in the early eighties. The new ships delivered after the boom added to the burden of a lower demand. This new depression was definitely the most severe since the Great Depression. At the peak lay up reached a high level of around 6%. There was no help coming from the tanker market either as demand for oil shipments dropped by a staggering 50% during the first half of the eighties, starting from an initial position of high surplus. This did not leave room for alternative employment for the shipyards. Throughout these years there was an abundance of supply of surplus tankers for scrap. This tended to depress scrap prices which reduced the incentive to scrap dry cargo ships. Shipbuilding capacity was excessively high in relation to requirements and the average age of the fleet was small. Subsidies to shipyards were increased. The process of cutting back costs by reducing the size of the labor force and restraining production was very slow. Metal prices had weakened considerably during the eighties tending to increase the supply of new ships and reduce the demand for scrap. Bunker prices were also falling this also having a depressing effect.

In 1987 the market staged a strong comeback after a series of years of severe depression. The strength of the 1987 market was partly a manifestation of the unavoidable long term recovery that follows a deep depression. Such depressions cannot last forever since the poor rates would not allow to recoup an investment in newbuildings even if they were bought at cost. These newbuildings are eventually needed to replace old ships and satisfy a growing demand. Scrapping capacity grew considerably during the eighties taking advantage of the availability of old ships at low scrap values. Accumulated cutbacks in shipbuilding capacity and labour force led to considerable permanent improvements on the supply side. Tanker rates, but mostly values, rose first in 1986 as demand stabilized after several years of negative growth. Prices rose partly in anticipation of favourable supply side developments. The increase of tanker values in 1986 led to a dramatic and immediate withdrawal of tankers from the scrap market. This led to a strengthening of scrap prices that brought forward an increasing supply of dry cargo ships for scrap to fill the gap left by tankers. The dry cargo scrapping rate rose to an all time high of 4.5% causing the first post war drop in the size of the dry cargo fleet. Although a drop in values was justifiable and necessary in order to adjust the size of the fleet, the market probably went too far in 1986 and caused an underpricing of ships. This actually contributed to the subsequent recovery by generating more scrapping and less shipbuilding than would otherwise have been forthcoming. Fig 1.35 indicates that by 1987 the freight market balance was approaching the average level around which it has tended to oscillate historically and to which it always tends to return.

1.3 Historical fluctuations in the tanker market

Fluctuations in the tanker markets have always been closely linked with events in the oil industry. Changes in the volume of production and its geographical distribution, which to a large extent determine the volume of transportation services required, have been very rapid during the whole history of the market. This history essentially began during the second half of the 19th century with the discovery and economic exploitation of the North East USA oilfields. This section considers how the major events in the oil industry and other external developments have affected the tanker market ever since 1861. Again three periods are distinguished. These are the pre-World War, the inter-War and the post War period.

1.3.1 The pre-World War I tanker market

During the beginning of the second half of the 19th century, substantial quantities of oil were discovered in the North East USA oilfields. This led to the beginning of the economic exploitation of this new source of energy. The oil produced there was transported by railcar and later on also by pipelines to the East Coast cities such as New York, Baltimore and Philadelphia. About 50% of it was destined for local East-Coast consumption while the remaining half was exported by ships to Europe and a small portion to the Far East. The first shipment was in 1861. Europe and especially Britain were at that time the center of world industrial activity that would generate most of the demand for oil. The European economy however was based on coal and the powerful interests vested in it would not allow oil to capture the big lucrative primary fuel markets before a long and hard fight. It was the old vegetable and animal fats and oils against which petroleum could immediately compete in the markets for lamp and lubricating oils.

The only available means of sea-transport which could carry the cargo from the US ports to UK/Continent where the traditional sail ships. Oil had to be loaded in barrels or tins which would then have to be stowed into the sail ships. This was obviously an inefficient and expensive method. Thus, during those first few years in the 1860's, freight rates on the Atlantic route could oscillate around the high level of 100 shillings per ton in order to make the voyage profitable and thus bring forward sufficient supply. This compares with the low rates of below 10 shillings that were paid during various years of the 1920's and 1930's by which time more efficient low cost transportation methods had been designed. These high rates, however, created the incentive for experimentation in the construction of specialized ships that would carry oil at low cost. Thus the first tankers were born which were designed to carry oil in bulk in their tanks. Some of these experiments failed badly with the ships exploding and disappearing in the Atlantic. The obvious riskiness of these new projects effectively acted as an increase in the capital cost of investing in tankers and thus rates had to be maintained at a strong level in order to make the building of these ships economically attractive. Indeed the first 50 years of the tanker industry are characterized by persistently very high freight rates which were never to be seen again for such prolonged periods of time. The lack of knowledge and risk capital would prevent a rapid increase in the size of the fleet. Equilibrium was established at a level were freight market balance would be tight and rates sufficiently high so as to induce risk taking in building tankers. Later on such high freight rates would be experienced only for short-lived periods or during abnormal situations such as world wars. This was because with the passing of the years the shipbuilding industry acquired the necessary knowledge, experience and resources to build sufficiently good ships while investors understood the new market better so that supply and demand for tankers would respond quickly to a shortage in the freight markets.

Certainly the sluggishness in the response of the supply of new ships to market conditions, was contributing towards maintaining rates at a high level during the 19th century. Equally important, however, were the very high growth rates in demand for seaborne oil movements which guaranteed that any tankers actually built would be quickly absorbed. Once the relatively efficient tankers were absorbed, the extra demand would have to be satisfied by dry cargo ships operating in the tanker freight market under the costly method of loading in barrels.

The growth rate of oil shipments from USA to Europe was maintained at the high levels of 20% in the 1860's, 10.3% in the 1870's and 9.6% in the 1880's. Following their first imports from the US, the Europeans soon realized the advantages of oil and went on to search for new oilfields closer to home. Substantial discoveries were made in Russia. The Baku oilfields by the Caspian Sea begun to produce oil in commercial quantities in 1871. In the beginning the whole output of these fields was transported to Moscow to satisfy local demand. There was no way at the time for the oil of the land-locked Caspian Sea to reach the Black Sea from where it could be loaded onto tankers. Thus in the beginning this new production had no direct impact on the ocean tanker freight market.

Meanwhile in America, Rockefeller's Standard Oil had monopolized the distribution system from the inland producing areas to the East Coast and used this power to monopolize the whole oil market in the US, Western Europe and the Far East. The Standard was destined to lose its monopoly in the Far East soon after a direct rail link between Baku and the Black Sea was established in 1883. With the major oil markets being under the monopoly of the Standard, the only outlets for exports from the Black Sea were Southern Europe and the long haul routes to the Far East. During those years tankers were not allowed to use the Suez Canal since the authorities considered them to be unsafe. In 1882 however, Samuels' specially designed tankers got permission to use the Canal to transport oil from the Black Sea to the Far East. With freight rates being high in those early years, this gave Samuel a considerable cost advantage over Standards' US oil which had to travel considerably longer distances on sail ships in order to reach the Far East. Thus the monopoly of Standard in the Far East market was broken up and Samuel set up a new company named Shell.

The direct effects of these developments on the average distance of oil shipments and thus on the demand for tanker services was negative as the short haul Russian exports via Suez displaced more distant exports from the US. In 1885 shipments from the Black Sea represented 10% of the volume of oil carried on the Atlantic route. Within a space of 15 years this had grown to represent half the amount of oil carried from the US to Europe. However the opening up of the link between Baku and the Black Sea increased the overall availability of supplies in the world oil market and thus allowed demand and trade to grow more rapidly than would otherwise have been the case. This certainly had a positive effect on the demand for tankers which probably cancelled out the negative effects of the drop in average distance. In any case such minor fluctuations in demand during these early years would have had little impact on freight rates (and thus the whole tanker industry) since those were mainly determined by the need to attract the marginal, high cost, dry cargo sail ships. At these rates the 'efficient' tankers carrying oil in bulk would have made a healthy profit. The main cost however in building tankers were their capital costs and the uncertainty associated with the development of completely new projects in a new market. The high rates however justified the taking of these risks.

By the beginning of the 20th century Russian output had surpassed that of the United States. In the tanker market however, Russian output was a less important source of demand as most of it was destined for local consumption in Moscow. The first two decades of the century saw the decline of Russian output and the appearance of new producing areas. Ever since 1905, with the first internal political problems, Russian production begun to decrease. By 1917 and the coming of the Bolshevik revolution it had almost disappeared from the international scene. New discoveries were made in the US Gulf, Texas California and Mexico. Rapid developments were experienced not only in the geographical distribution of production but in the pattern of consumption as well. These would bring about considerable structural changes in the tanker freight market with the emergence of new routes and the decline of old ones.

Up to that time industrial activity was concentrated in Europe and generated a significant proportion in the total demand and trade in oil. In 1900 Europe was consuming 50% of world oil production while the US only 20%. Still, oil only accounted for 2.5% of world energy consumption. Kerosine was used in the illuminating market but other oil products such as fuel oil had not yet managed to gain any market share from coal. Ships, railways, and industrial plants were still being fueled by coal. Industry and transportation were the markets that oil had yet to penetrate. Fuel oil was used only near the oil wells themselves especially if coal was not available.

The US lagged far behind in industrial production but this would not last for long as it had the advantage of cheap local oil and an abundance of natural wealth of minerals and cultivable land. Europe not only lacked most of these resources but also had the additional disadvantage of being under the dominance of coal. This created a natural resistance to rapid change in energy sources towards more economical oil. Moreover the two World Wars destroyed much of the wealth and industrial power of Europe.

Technological innovations of that period created new more economic engines running on oil. Some of these developments created completely new markets. The revolution which had the biggest impact was the internal combustion engine. Karl Benz developed a machine running on benzine or gasoline and in 1908 Henry Ford launched his new 'Model T'. In the space of 10 years, from 1910 to 1920, car ownership in the US rose at an annual rate of 33% while at the same time the growth rate of the track fleet was 27% p.a. These new vehicles generated a considerable increase in the demand for fuel. Railways and ships also started to turn to fuel oil. In 1892 an alternative internal combustion engine also appeared. Dr Rudolf Diesel's invention was designed to run on any fuel but gas oil also known as diesel or fuel oil gave the best results. It was soon used to propel ships but was also useful on land.

Acceptance of oil in the big European industry and transport markets was slow. In the US however industry quickly turned to fuel oil. Demand for oil in most parts of the US could be satisfied from local production and thus created no demand for tankers. It was however in the East Coast were most of the industrial activity and expansion was concentrated and the supplies from the North Eastern fields which arrived via pipelines were not sufficient to satisfy the demand. Thus whereas East Coast ports were the major exporting terminals in the 19th century, exports would now completely cease and the area would become the major importer and would keep this position until World War II. These imports would have to come from the new producing areas of Texas, US Gulf, California and Mexico. The same areas would begin to export to Europe but this Atlantic trade lost its relative importance as US inter coastal flows into the East Coast came to dominate the tanker freight market. Exports from Texas could reach the East Coast either via pipelines linking into Standards' network or through the US Gulf ports by tanker. The second method was not only cheap but was also independent of Standards' grip. Thus a tanker route would again allow local producers to avoid the monopoly of the Standard and get a market share, this time out of the major East Coast market. Thus two new companies would be formed based on their production from their South American fields, Texaco and Gulf Oil. Average distances in the tanker markets would fall, as now much more oil would be flowing on the short-haul, local US routes than on the Atlantic route. This however did no harm to the tanker market since the growth rate of shipments along the Atlantic route was maintained. Imports into Europe from the East Coast were replaced by imports from the Gulf. Overall demand in the tanker markets increased as the growth rates in the short haul routes accelerated while those on the long haul Atlantic and Far East routes were maintained. This pattern of increased US coastal shipments and decreased relative importance of the Atlantic and Far East routes, was to continue until the Second World War.

1.3.2 The interwar tanker market

The two World Wars created a significant shortage in the shipping markets as can be seen from the long term graphs of Fig. 1.68-1.76. Major wars have a direct, significant impact on both the demand and supply of ocean dry cargo and tanker transportation services. The effect on demand is as big as the effect on supply. Modern war operations generate a big demand for fuel. The safer routes are not necessarily the shorter ones so average distances increase. There is a big impact also on the size and productivity of the fleet. It can be seen that both World Wars brought about very significant reductions in the dry cargo and tanker fleets as a result of naval warfare and the sinking of enemy ships. Most importantly the productivity of the fleet falls as ships have to move in convoys which implies a higher average waiting time in port. Other inefficiencies also occur as the fleet passes under the control of the governments which are more interested in the logistics of war than in cost minimizing transport. The net effect of such changes in demand and supply conditions is to send freight rates and ship values sky rocketing.

The wars usually also have a longer term impact on the shipping markets. This is because of the war shipbuilding programs which are undertaken in order to satisfy the increased demand, compensate for the decrease in productivity and replace the ships that have been sunk. Because of this, the growth rate of the fleet rose very rapidly during the later phases of the World Wars as can be seen from the charts. This led to significant surpluses appearing in the post war markets when demand returned to normal levels while the productivity of the fleet also increased.

Thus after the Great War the tanker market became depressed as demand returned to normal levels while the fleet had just risen significantly as a result of the war shipbuilding programmes. It can be seen from Fig. 1.53 that deliveries in 1921 amounted to over 22% of the fleet at a time when demand was slowing down and fleet productivity was increasing. However the 1920's were also years of very high growth rates of demand that would absorb the initial surplus. According to Koopmans (1939) worldwide demand for tanker ton-miles increased by an annual average of 12.9% during the first 5 years of the 1920's and then by an average of 9.7% in the remaining half of that decade. As always, this average growth rate was not evenly distributed over the years. As a result, the tanker market experienced various profitable short lived booms whenever the growth rate of demand rose above its trend. These would be followed by rather longer periods of depression as soon as the growth rate of demand receded and/or the fleet rose in response to the previous boom.

By that time the knowledge needed for building safe tankers had already been acquired partly through trial and error. Other factors also contributed to a lowering of the capital costs of investing in tankers such as the increased familiarity of investors with the tanker market and the increased willingness and capability of independent owners to enter the market with their own risk capital. These developments had helped to bring the shipbuilding industry into a position where it could increase the growth rate of the tanker fleet very rapidly as soon as the market conditions improved. This would eliminate quickly any large shortages and abnormal increases in rates. Initially the shortage would be

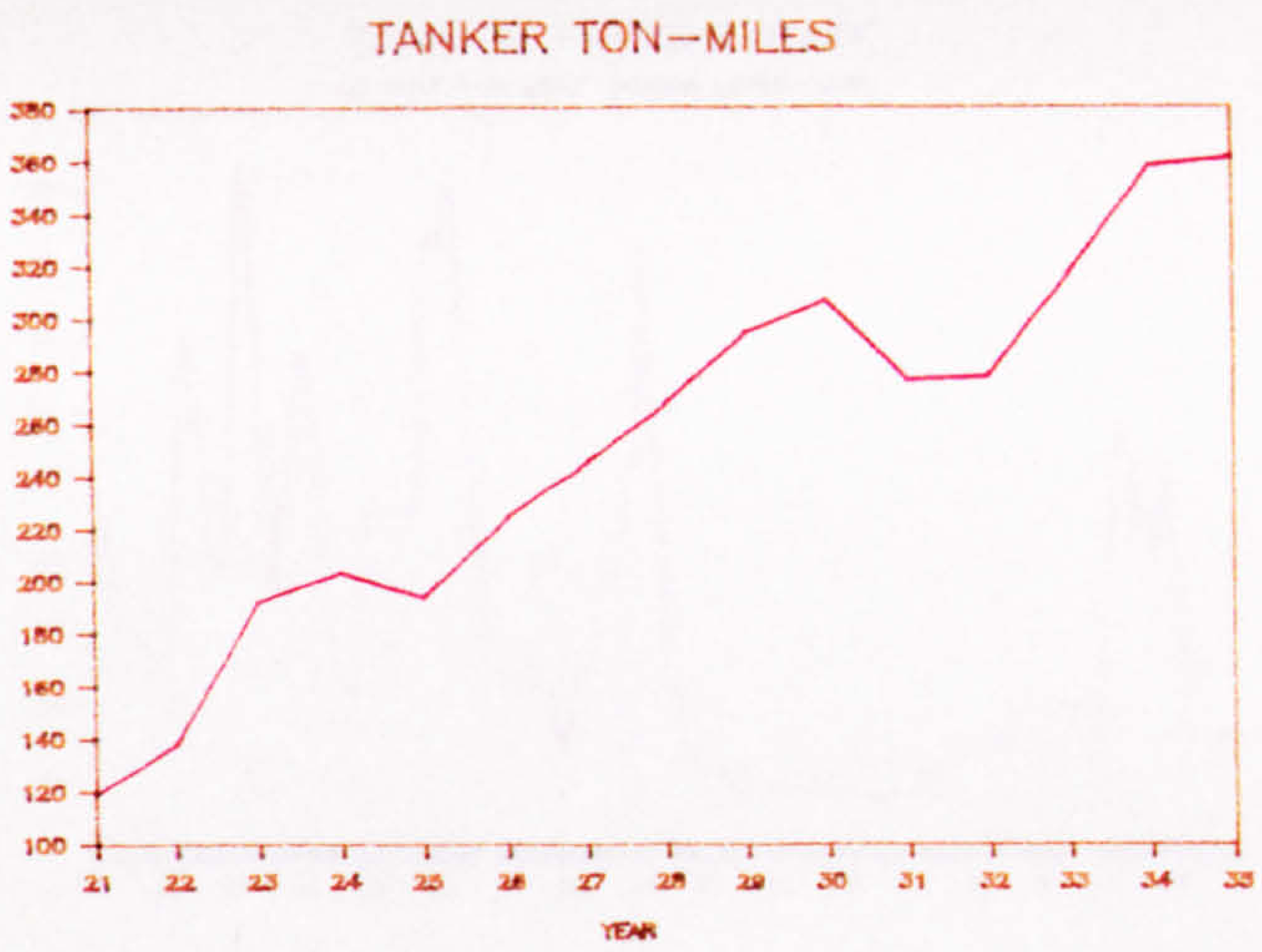

FIG. 1.46

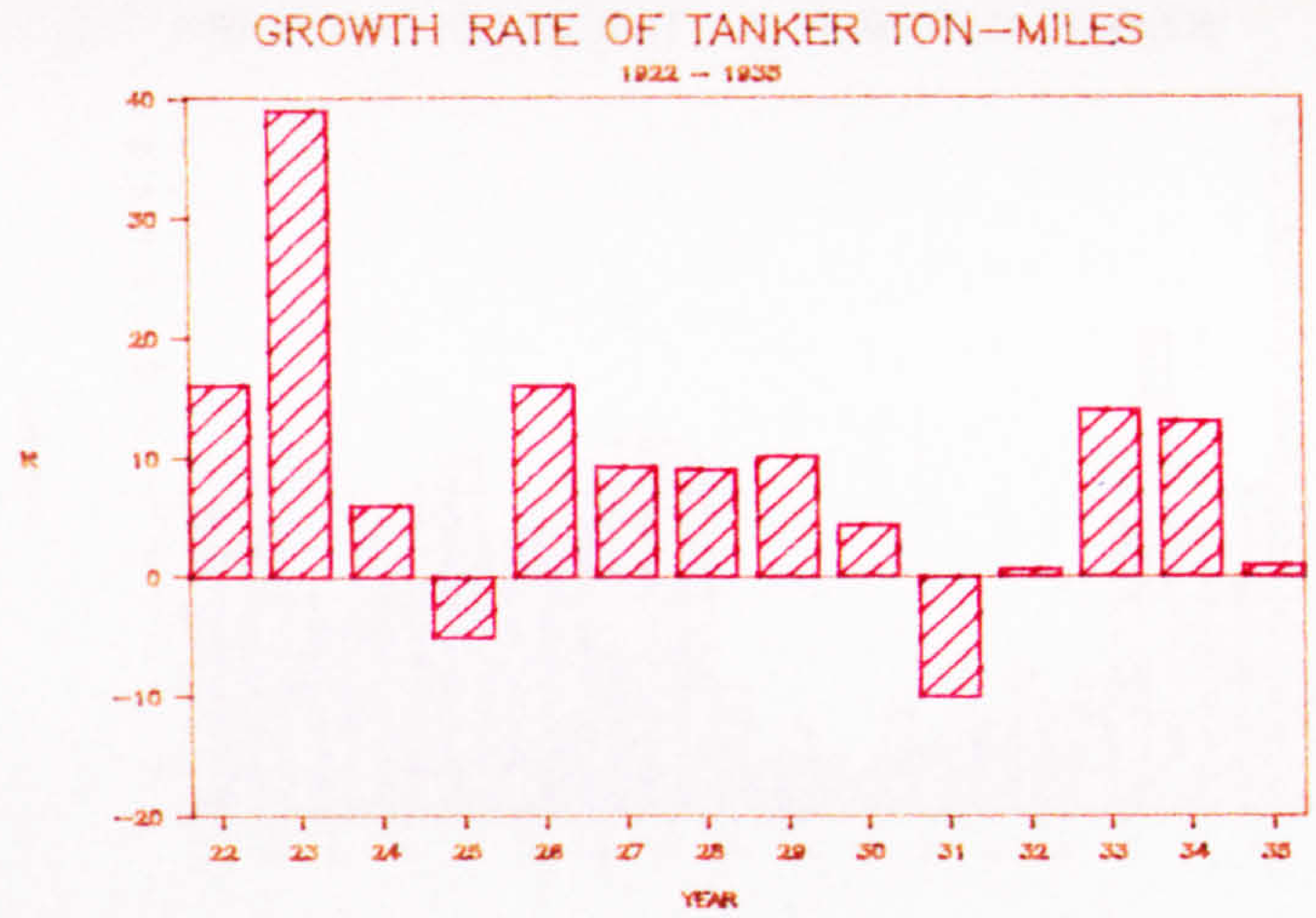

FIG. 1.47

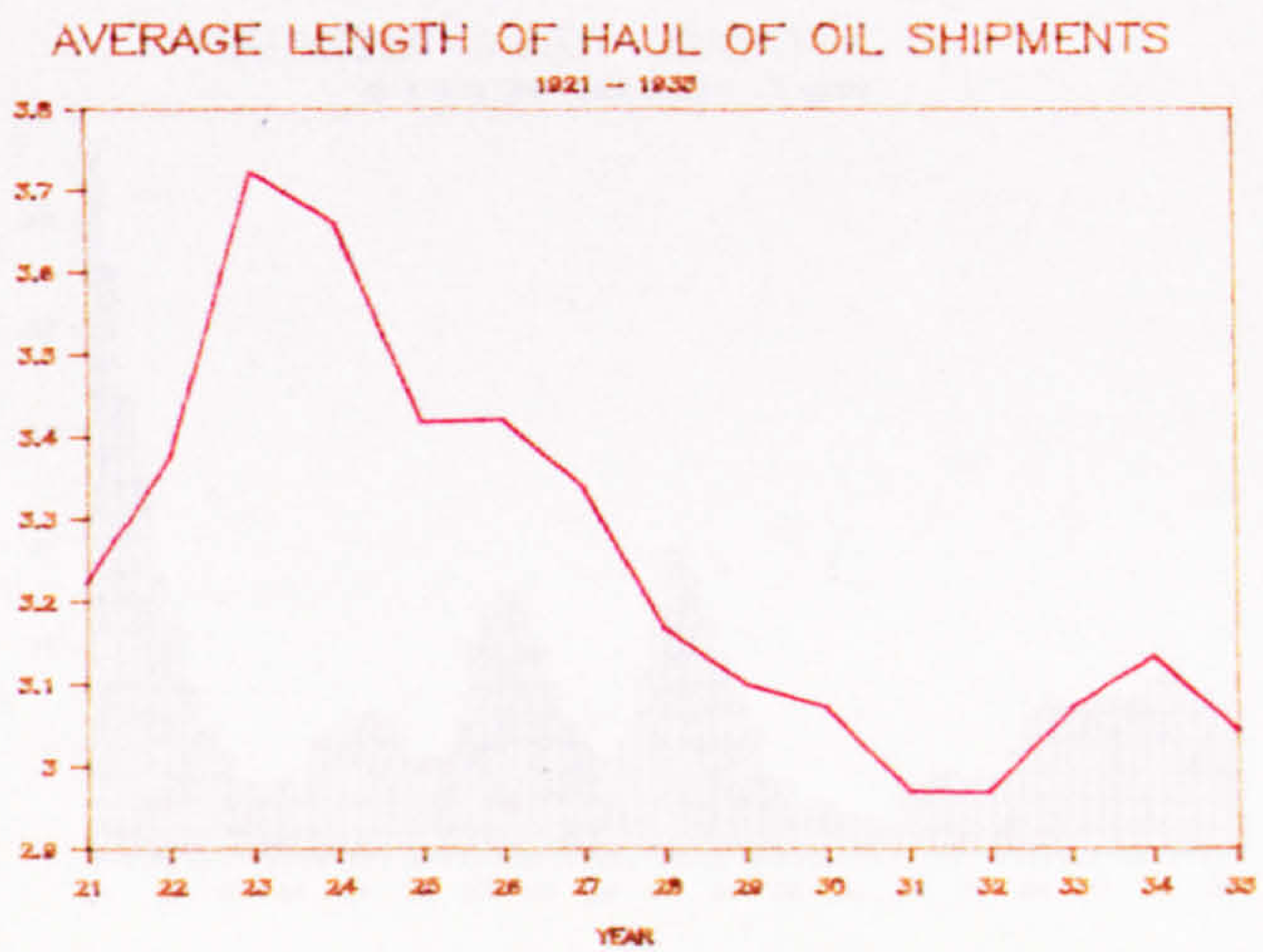

FIG. 1.48

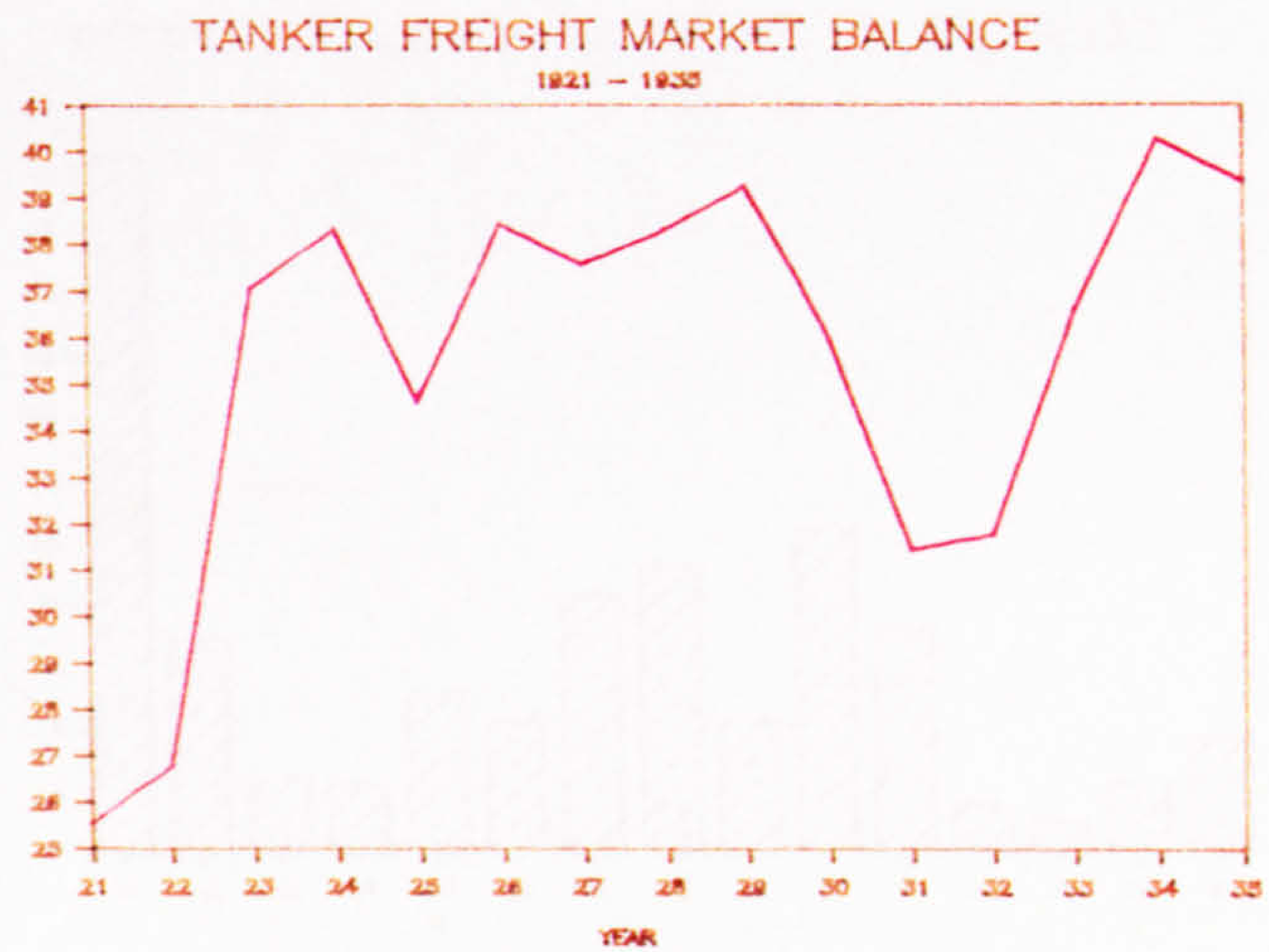

FIG. 1.49

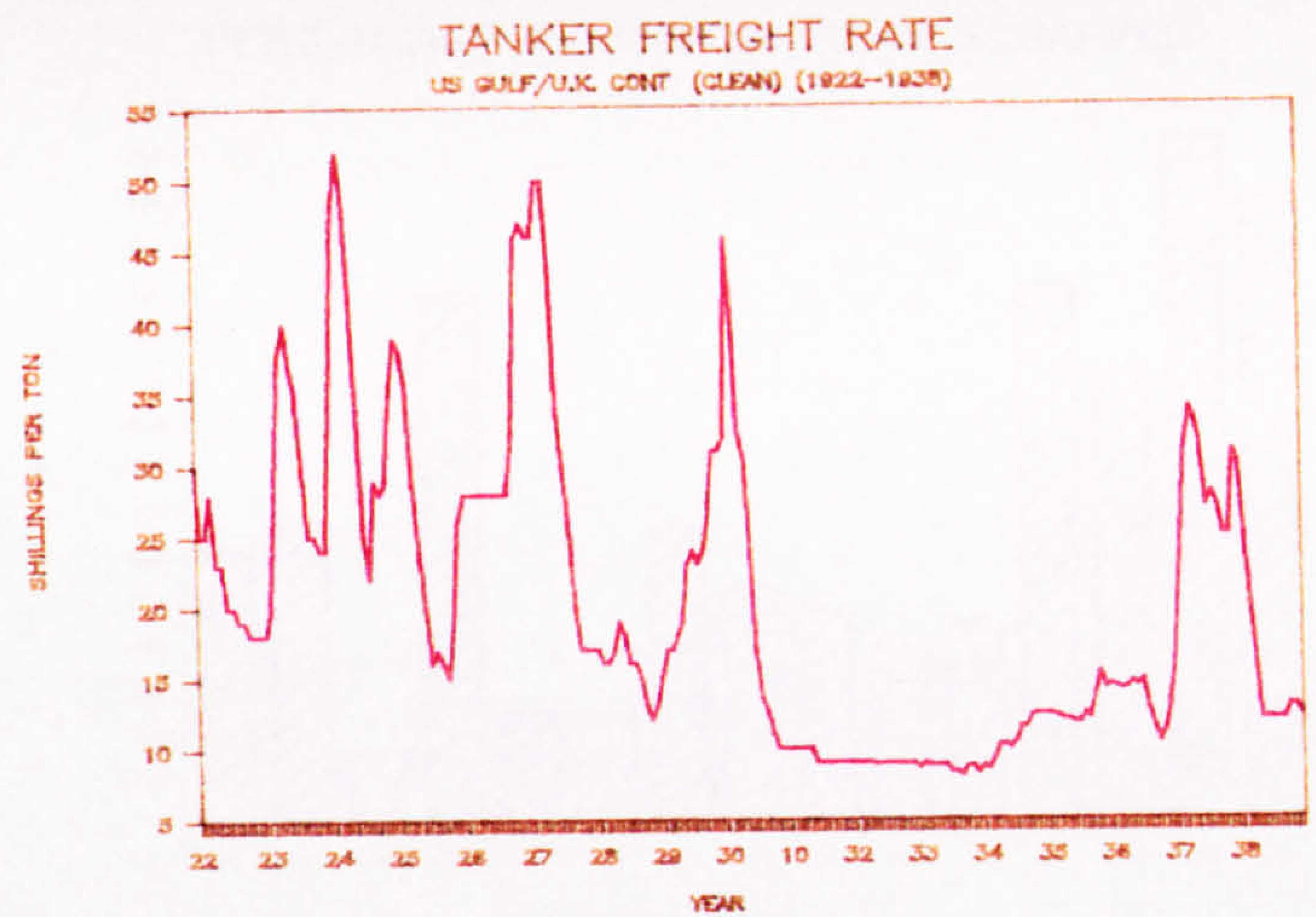

FIG. 1.50

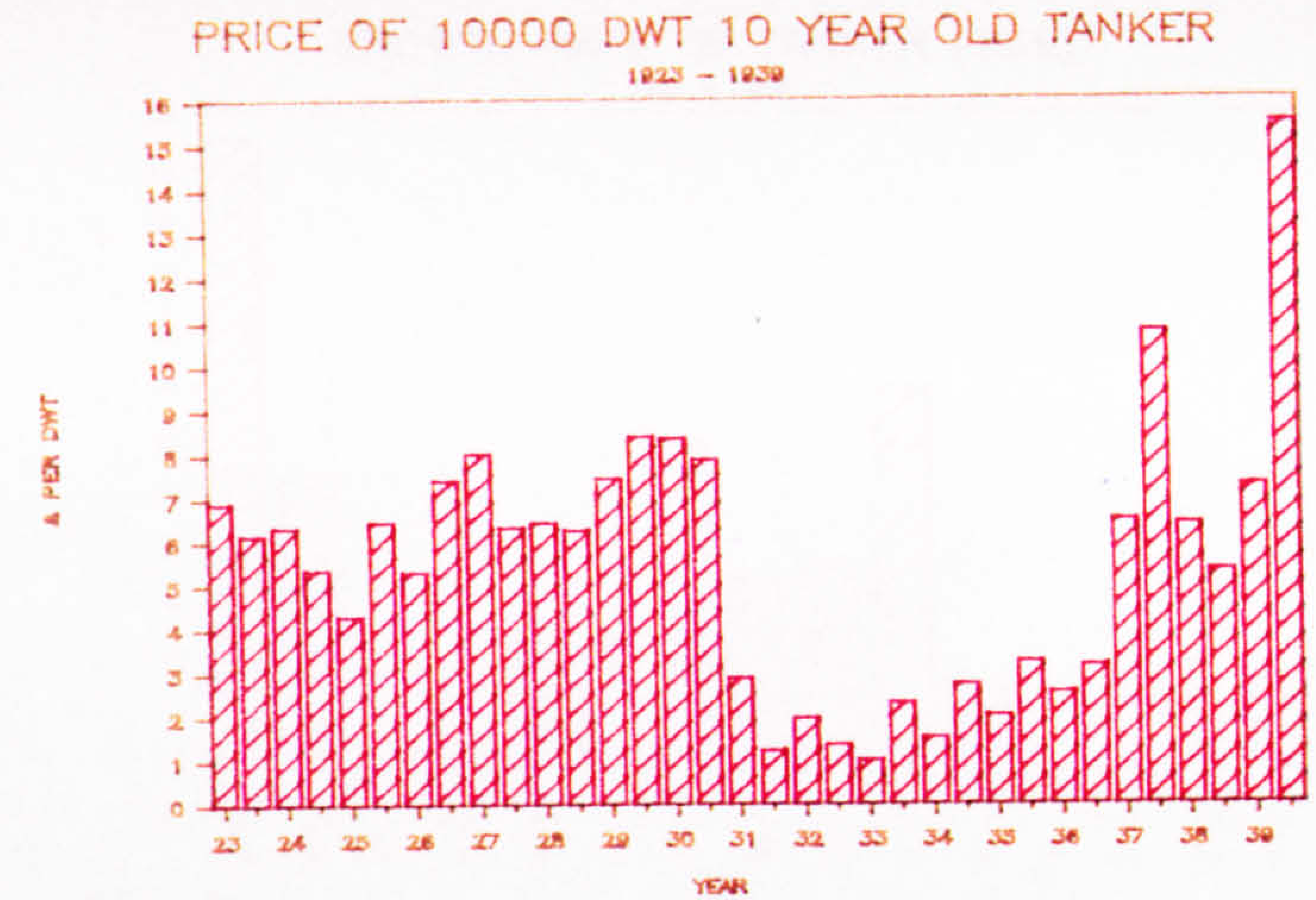

FIG. 1.51

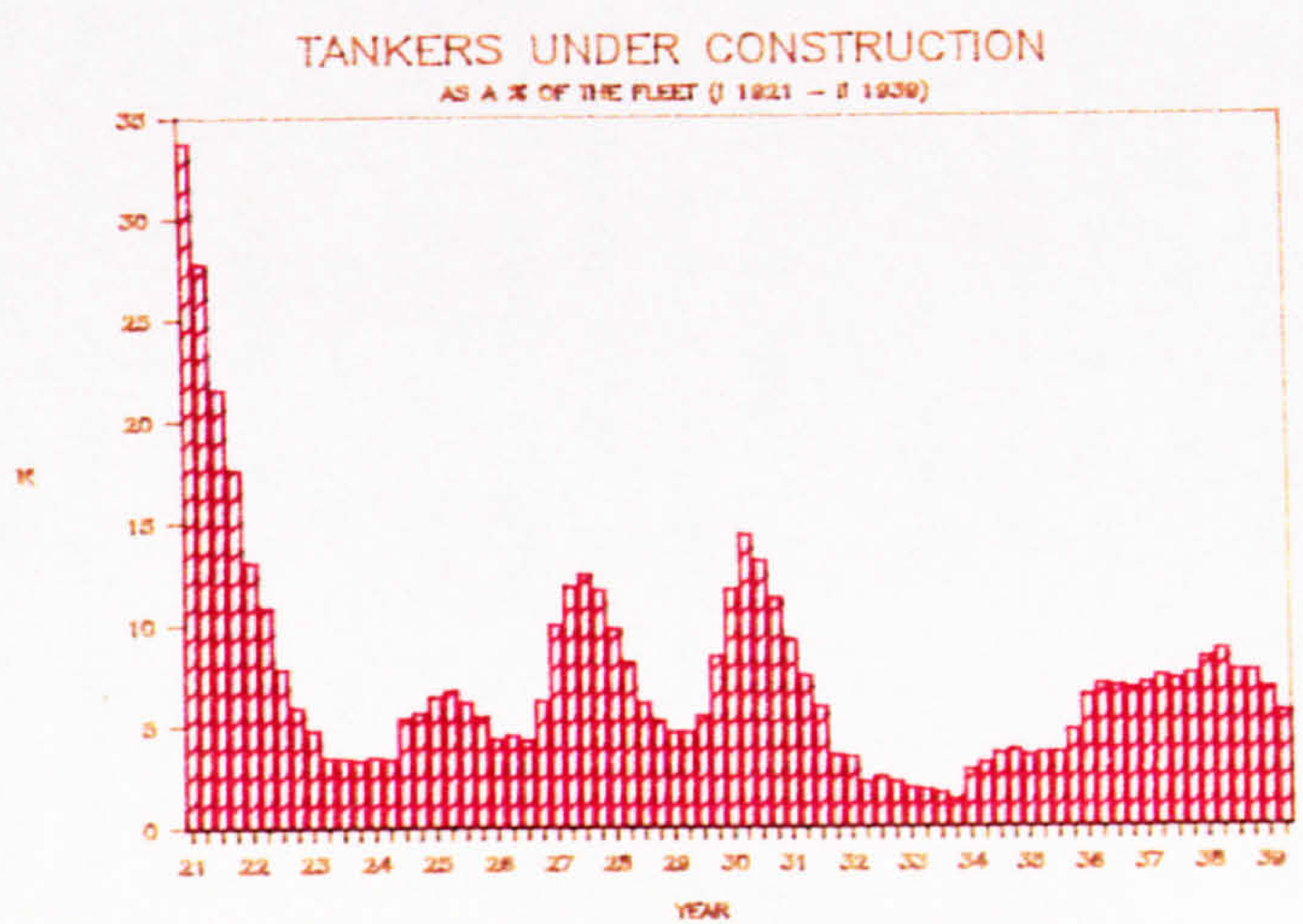

FIG. 1.52

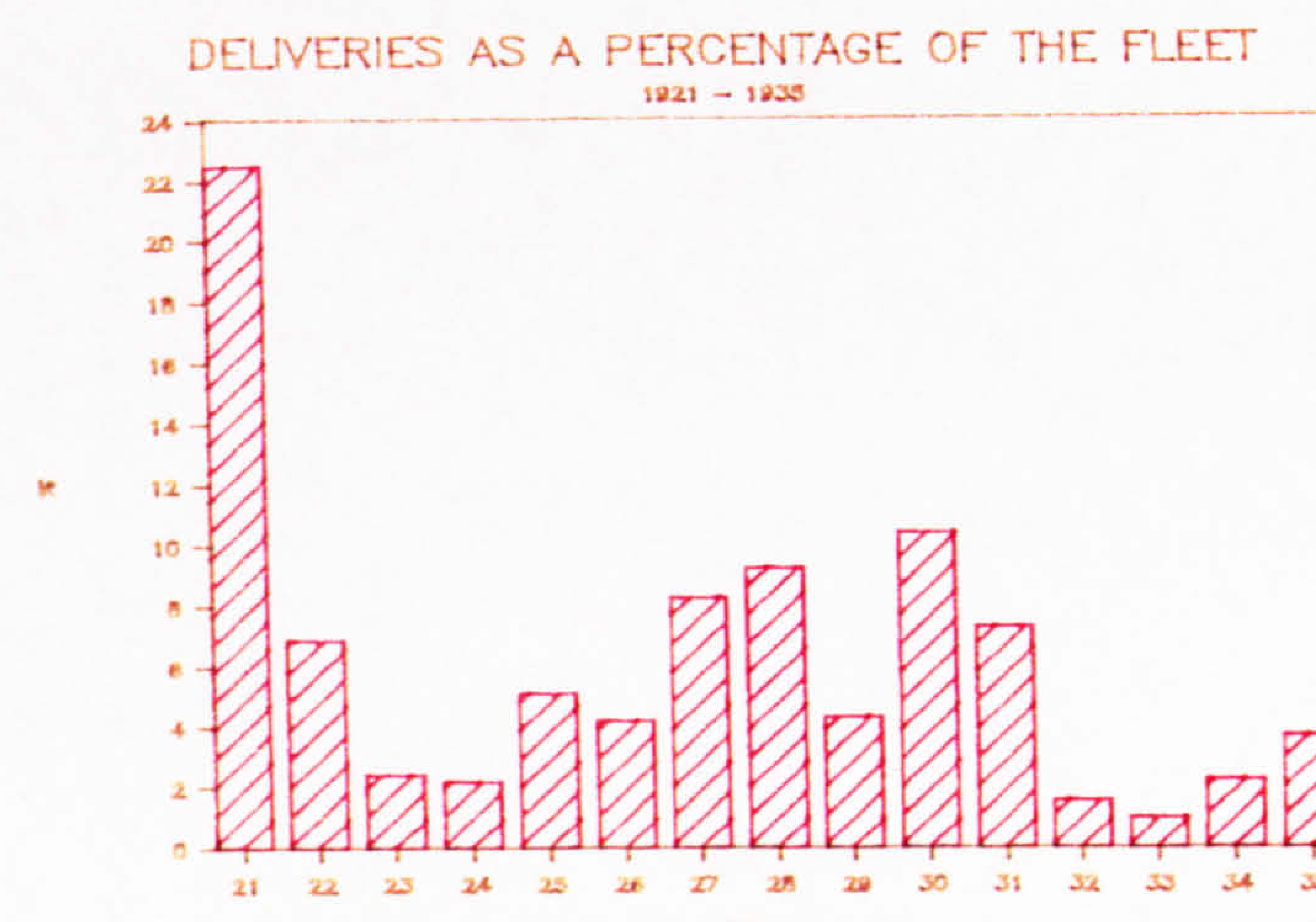

FIG. 1.53

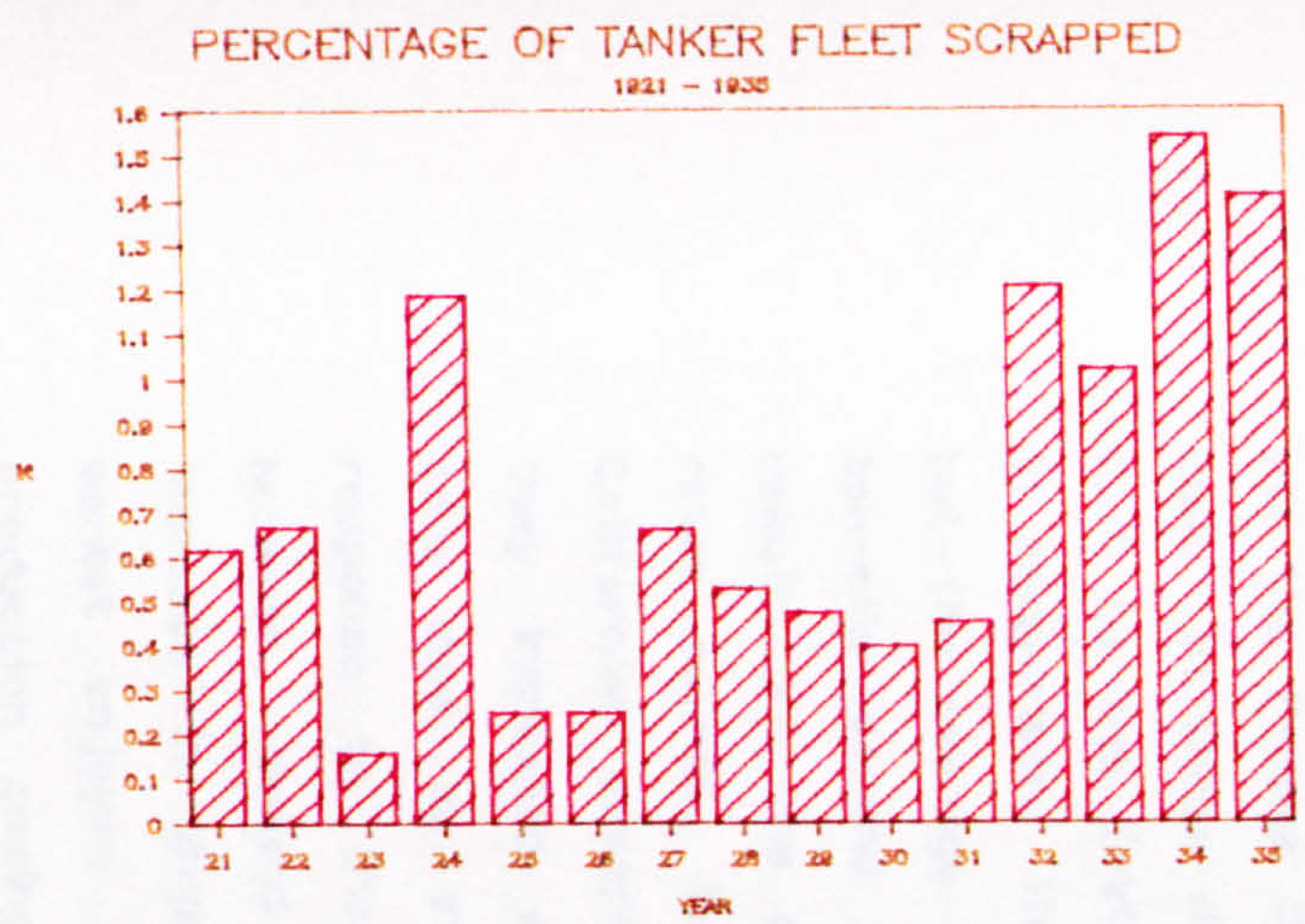

FIG. 1.54

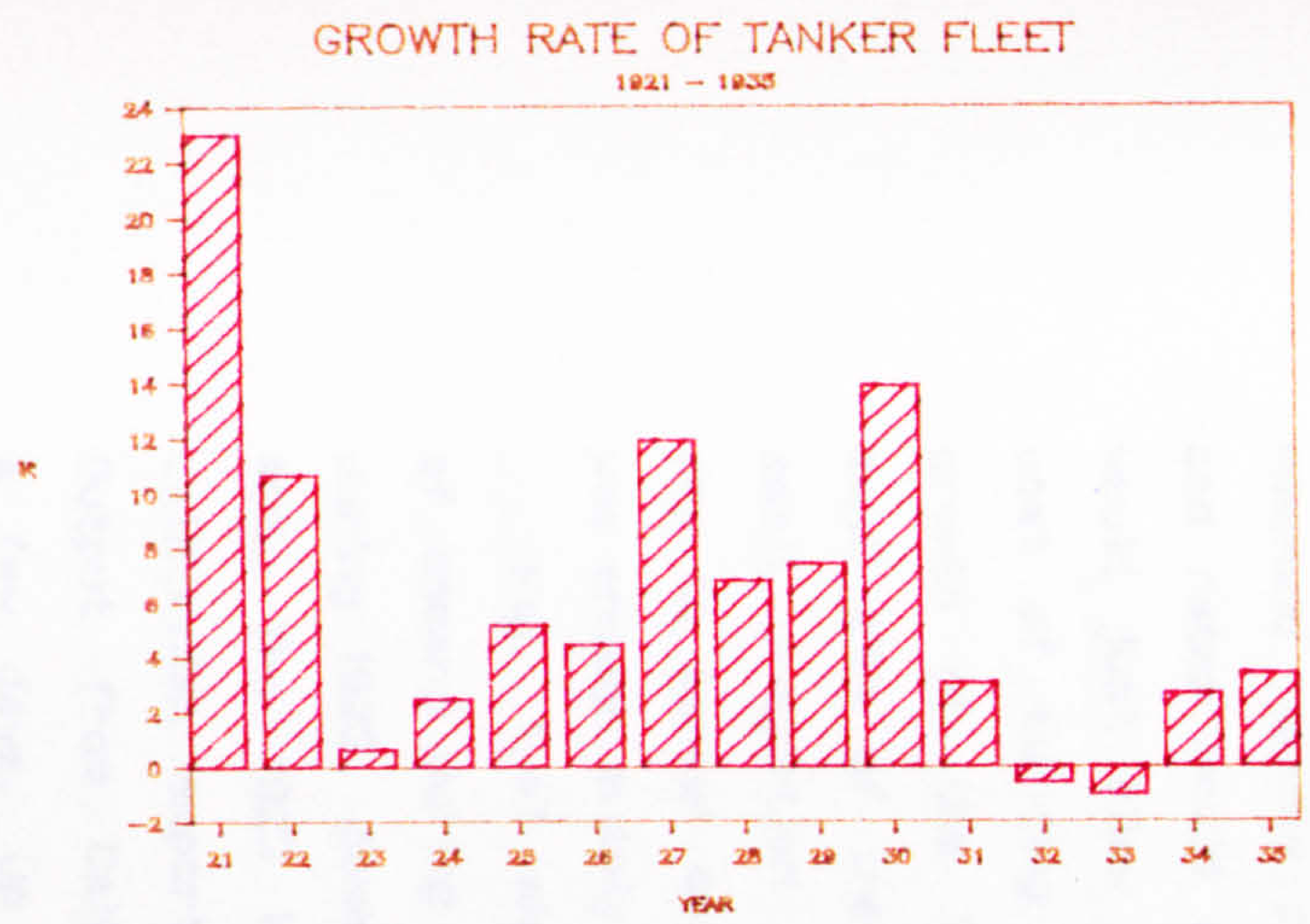

FIG. 1.55

satisfied by increased participation of dry cargo sail ships carrying oil in barrels. But the fleet would respond rapidly pushing the sail ships out of the market and rates would soon go down to or below the level that would just allow a sufficient return to be earned on the cost of building tankers at a rate that would keep the growth of the fleet in line with that of demand. The small size of the tanker sector meant that it only took a small proportion of shipbuilding capacity to switch from dry to tanker construction, in order to ensure that there was enough supply of new tankers to bring rates down.

Fig. 1.47 shows the fluctuations in the growth rate of demand during the inter-war years. It can be seen that during 1923, demand rose by the enormous amount of almost 40%. The 1923 boost in demand was due to the sudden Californian export boom to the US via the Panama Canal. Output from Californian oilfields suddenly doubled within a few days. Up to that time all Californian output was absorbed by local consumption. There was no way that the sudden big increase could be absorbed by local consumption anymore, so shipments began to the East Coast via the Panama Canal and to a lesser extent to the Far East. In those days when most of the trade was from the Gulf to the East Coast, these new routes were long-haul in comparison. Thus not only the volume of trade went up but the average distance rose too, causing the volume of ton-mile demand to grow by 39% within a year. As a result, all the postwar surplus was quickly absorbed and rates soared. Two years later demand dropped by 5% as Californian exports began to decline almost as quickly as they increased and the market became depressed. Rates came down as in the meantime the fleet was growing in response to the previous boom. In the following year, however, demand grew by 16% thanks to an all-round increase in shipments to the East Coast. In 1929 the market enjoyed another good year thanks to Venezuelan production coming on stream and the strong consumption demand for oil.

The high growth rates for oil transport during the twenties, implied that, unlike the dry cargo market, the tanker freight balance was tight on average. Only this way would rates be strong enough to create an incentive for the system to expand the fleet rapidly in line with the growth in demand. Rates and prices (Fig. 1.51) were indeed strong on average. The latter was necessary in order to make shipbuilding profitable and bring forward the necessary supply of new ships. The tightness of the market implied that any spurt in demand would tend to push rates to very high levels.

However, during the first half of the thirties the market experienced its worst depression. This was partly due to an ordering boom which was fueled by the consecutive booms of the 1920's and in turn caused the fleet to grow by 7.5% and 13.9% in 1930 and 1931 respectively. At the same time demand dropped by 10% in 1931 in line with the drop in the general level of activity associated with the Great Depression. The worsening of the freight market balance led to freight rates falling to their lowest possible level determined by operating and lay up costs. Prices of tankers fell to all time lows. This led to a contraction in shipbuilding and an increase in scrapping (Fig. 1.54) which in the long run helped the market to return to normality.

From 1933 onwards demand begun to increase at the considerably high level of 13% p.a and this led to a significant increase in rates so that part of the capital costs could also now be met. Another contributing factor to the increase in rates was the formation of the Tanker Pool during 1934. This is one of the rarest examples of a partly successful cartel formed by shipowners in order to raise rates. As is well known cartels can only manage to raise prices, if they succeed to restrict the supply forthcoming from its members, at a level which is lower than what would be forthcoming if the market was competitive. The cartel must control a significant proportion of the total potential supply in order to be successful. Otherwise it will find that just as it tries to withdraw supply from the market in order to raise rates, the non members (which are not bound by any rules of the cartel regarding price and output) will raise their supply in order to take advantage of the higher prices. This will frustrate the price hike since cutbacks by the cartel will be partly cancelled by increases in the supply from the non cartel producers. This will require significant and possibly unacceptable sacrifices in output from the cartel in order to raise prices. Most of the benefit of the higher prices will,however, go to the non members who will be able to expand their supply while members will lose much of the benefits of the high price because of the necessary cutbacks in their own production. The strict self-interest of a member will then be to get out of the cartel so as to be free to raise output and take advantage of the higher price. If that happens the cartel tends to disintegrate rapidly. As more members leave and expand their supply the higher will be the sacrifices that the remaining members will have to make so that they will be less likely to stay. Thus cartels tend to be unstable and the market tends to return to the competitive situation.

This indeed was exactly what happened with earlier efforts by a group of Norwegian tanker owners which formed the "Tankskibscentralen" cartel. The group was set up in January 1933 and had all the fleet of its members under central control. Profits would be distributed to members in proportion of their tonnage. This scheme was naturally abandoned in September 1933 as it didn't have the necessary support. In order to raise rates the group had withdrawn supply by raising its proportion of laid-up tonnage. As rates responded slightly the group found that the non members had taken their ships out of lay-up in order to reap the profit generated by the higher rates. The individual interest of a member was to get out of the cartel so as to get more of his ships back to the market and so the group disintegrated.

A cartel is more likely to be successful if it has the power to penalize those members who violate the rules set by the group in order to pursue their self interest.

Indeed, it was not the simplicity and ingenuity of the cartel's scheme by which it aimed to increase rates that led to its success, but the fact that the powerful oil companies supported it. The shipping departments of the oil majors participated in the cartel by undertaking not to charter any ship that was not entered in the Pool. Immediately all owners joined the cartel since the alternative option would imply very little business for their ships, as the oil majors were the main charterers.

The mechanism through which the cartel aimed to raise rates was as follows: Members undertook the obligation to the Pool to pay a certain percentage from all their freight earnings. Then the Pool would distribute these funds equally over all laid up tankers. The main advantage of the this scheme was that it did not impose any compulsory restrictions on the supply that its member would wish to offer to the market. Each member was free to pursue its optimal strategy under an incentive scheme that tended to reward the laying-up of a vessel and reduce the profit from sailing.

However, it must be stressed that the Pool would not have been successful if the major oil companies had not given their support. It might seem strange that the oil companies should give support to a scheme that aimed to increase the price of a service of which they were active buyers. The explanation lies in the fact that whereas the major oil companies carry most of their oil on their own ships, the independent oil producers have to rely completely on the freight market. An increase in freight rates was expected to hit the independent producers and give a cost advantage to the majors who were the bigger owners of tankers. The increase in costs was also expected to restrict supply from the independents and lead to an increase in the price of oil that would compensate for the higher freight rates.

By the time the cartel came to be established, demand had already begun to rise strongly and the freight market balance had begun to improve. Rates, prices and shipbuilding were also gradually recovering until in 1937 the market boomed. It was now the European industry that was rapidly turning to oil and was generating this growth with its long haul imports from the US and the Middle East which was slowly beginning to emerge as a new producing area. In 1935 the Middle East generated 15% of the total demand for tanker transportation services. With the coming of World War II the peace time trade flows would be disrupted once again and the same factors would come to dominate the market as during the Great War. Indeed the market followed an identical path during both Wars with rates and values booming, the fleet being reduced initially as a result of bombings, while later on the increase in shipbuilding output would more than compensate for the early losses. The new ships would overhang the market once the War was over.

1.3.3 The post War tanker market

The whole 1950 to 1987 period can be easily divided in two parts, pre and post OPEC, with 1973 being the border year. The first is a period of uninterrupted expansion and it is characterized by extremely high average growth rates in demand. The second is a period of stagnation and rapid decline in shipments caused by OPEC's price/production policies.

The pre OPEC period

During the 1950's the oil industry expanded as rapidly as it did during the first half of the century. European industrialized countries had destroyed most of their wealth including their coal industry. This made the transition to oil easier. Throughout the third quarter of the century the world economy experienced very high growth rates partly thanks to cheap oil. Industrial production in OECD countries expanded rapidly while less developed countries also began to industrialize. The demand for oil grew even faster as at the same time a rapid transition from coal to oil was occuring in Europe, Japan and to a lesser extent in the rest of the world. But demand in the tanker market was growing even faster as average distances were rapidly increasing creating extra demand on top of that generated by the general increase in the volume of oil production and trade. Thus whereas seaborne trade in oil grew at an annual rate of 9.3% p.a. over the period 1950-1973, demand for tanker services grew at the faster rate of 11.9% reflecting an additional 2.6% p.a. increase in average length of haul.

The reason for this, was the rapid increase in production from the vast Middle East oil fields. European growth in the demand for oil was totally satisfied by long haul shipments from the Middle East which completely displaced the relatively short haul imports from the US. Japanese demand became also totally dependent on Middle Eastern production. Indeed the Persian Gulf became the focal point of the tanker market as most of the oil trade was moving on these new routes to Europe and Japan. These involved considerably higher distances than the major Latin American, US intercoastal and Atlantic routes of the first half of the century.

Within the 1950 to 1973 period one can further distinguish three distinct phases. 1950 to 1957 was a period of strong growth rates in demand. 1958 to 1966 was a period when growth rates fell while the fleet was rising strongly as a result of previous false optimistic expectations and innovations in the shipbuilding industry which led to the construction of ever bigger and cheaper tankers. The third phase is from 1967 to 1973 and is characterized by extreme growth rates in demand as the previous post war record of 15% was exceeded in almost every year.

The high growth rates observed during the 1950 to 1957 phase were directly related to the rapid expansion in oil consumption and Middle Eastern production. During this period, demand grew at an annual compound average of 10.6%. The fleet rose at an average rate of 8.2% p.a in dwt terms, but because of the higher speeds of the new ships, the growth in effective capacity terms was much

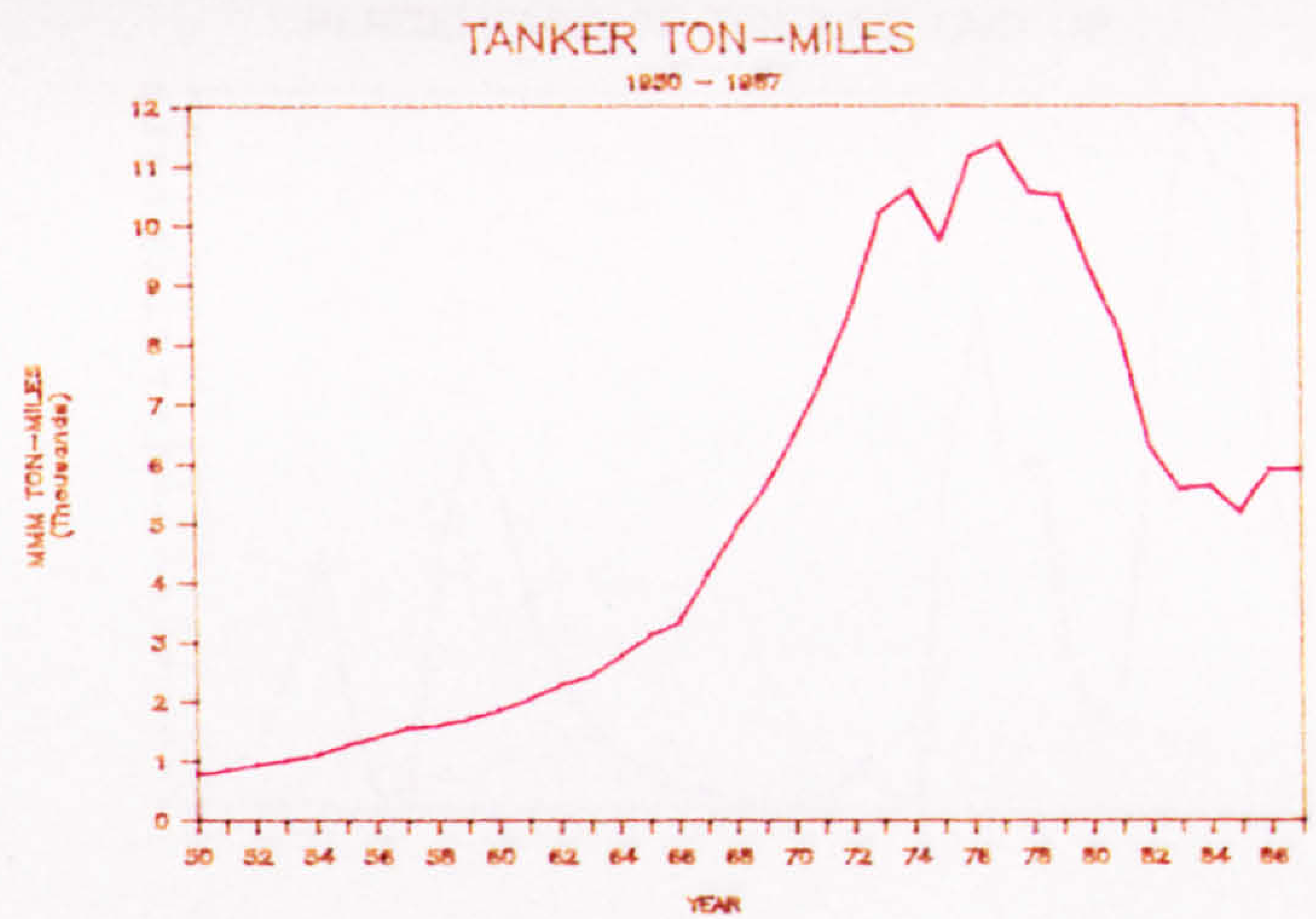

FIG. 1.56

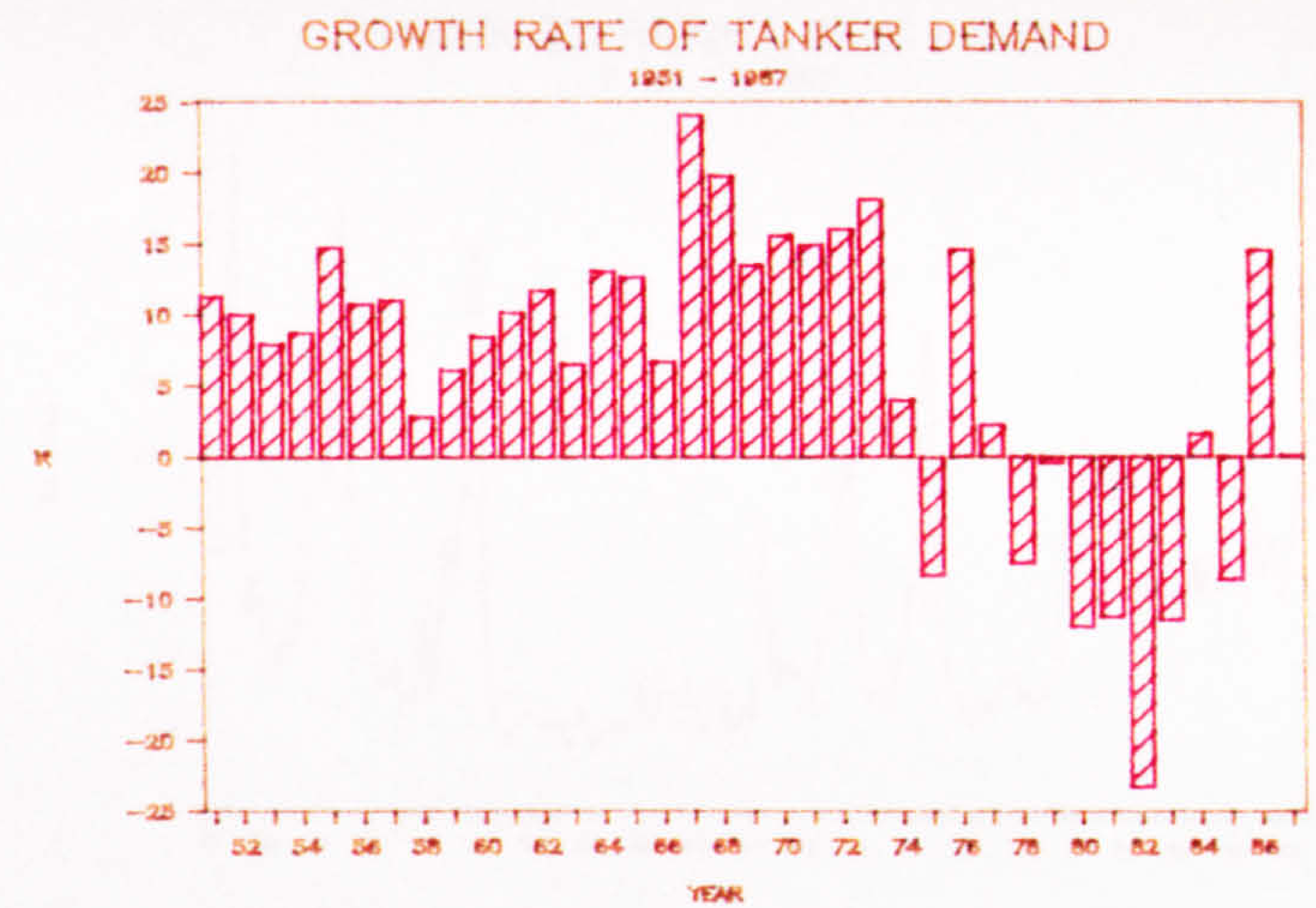

FIG. 1.57

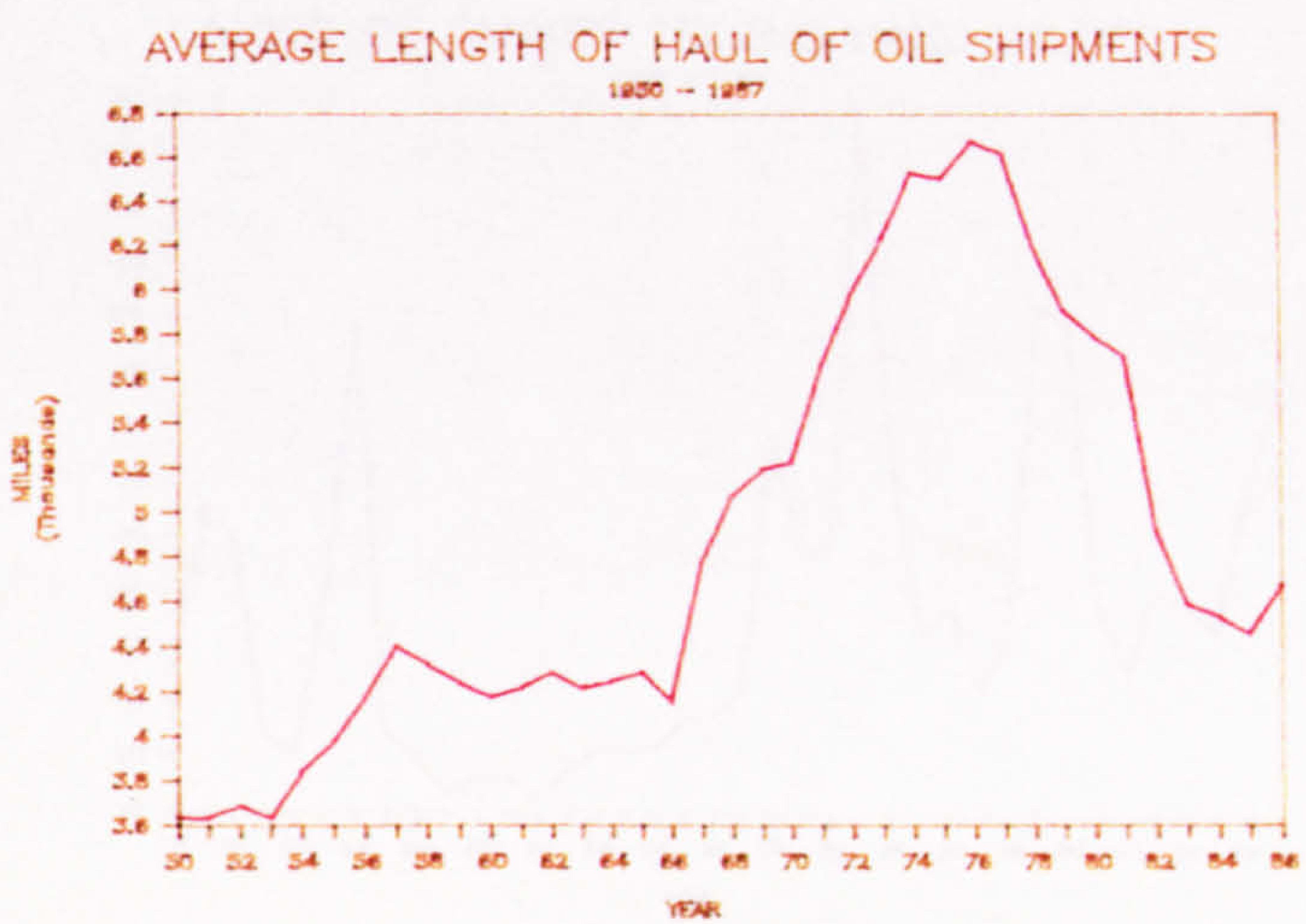

FIG. 1.58

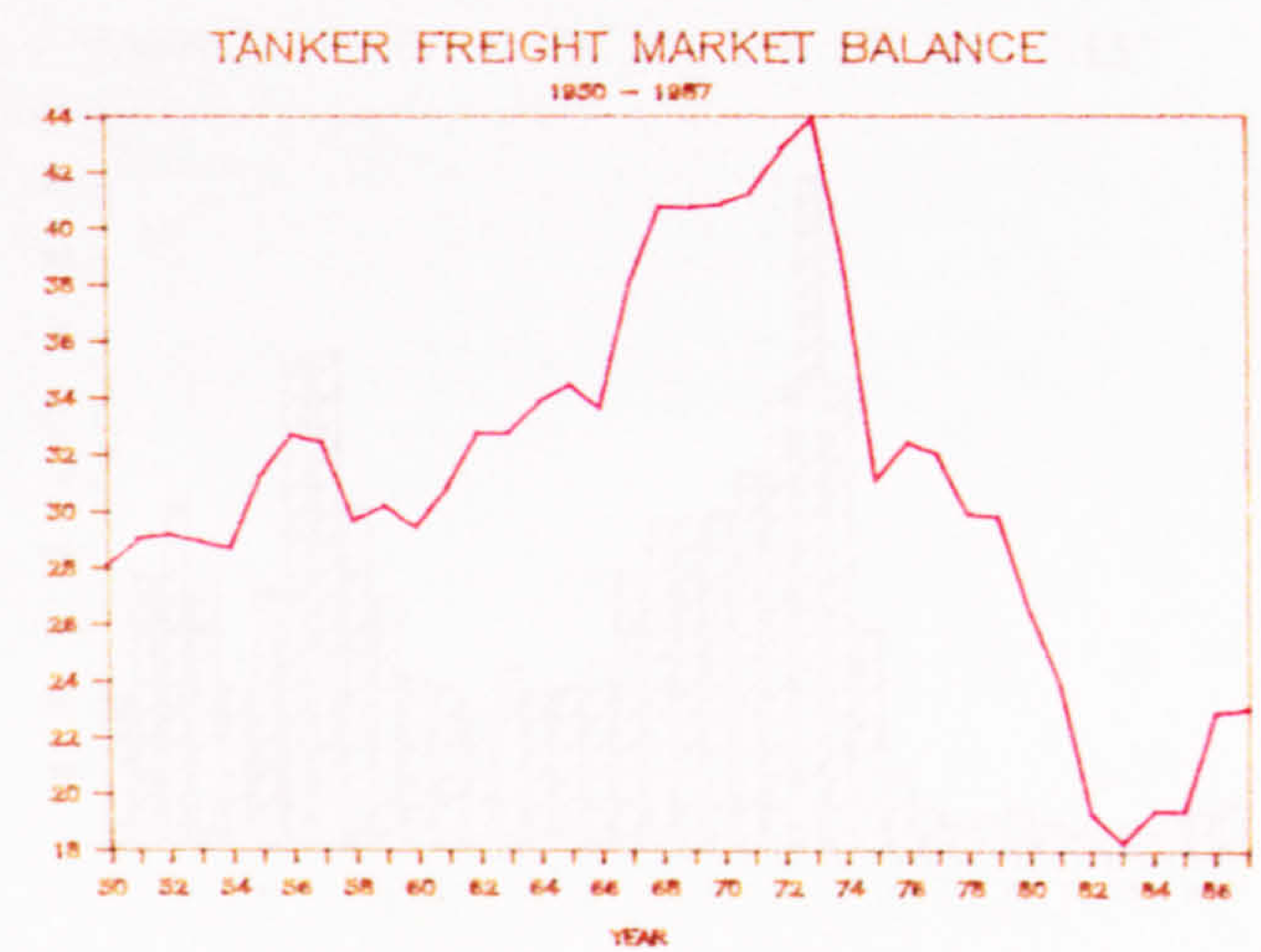

FIG. 1.59

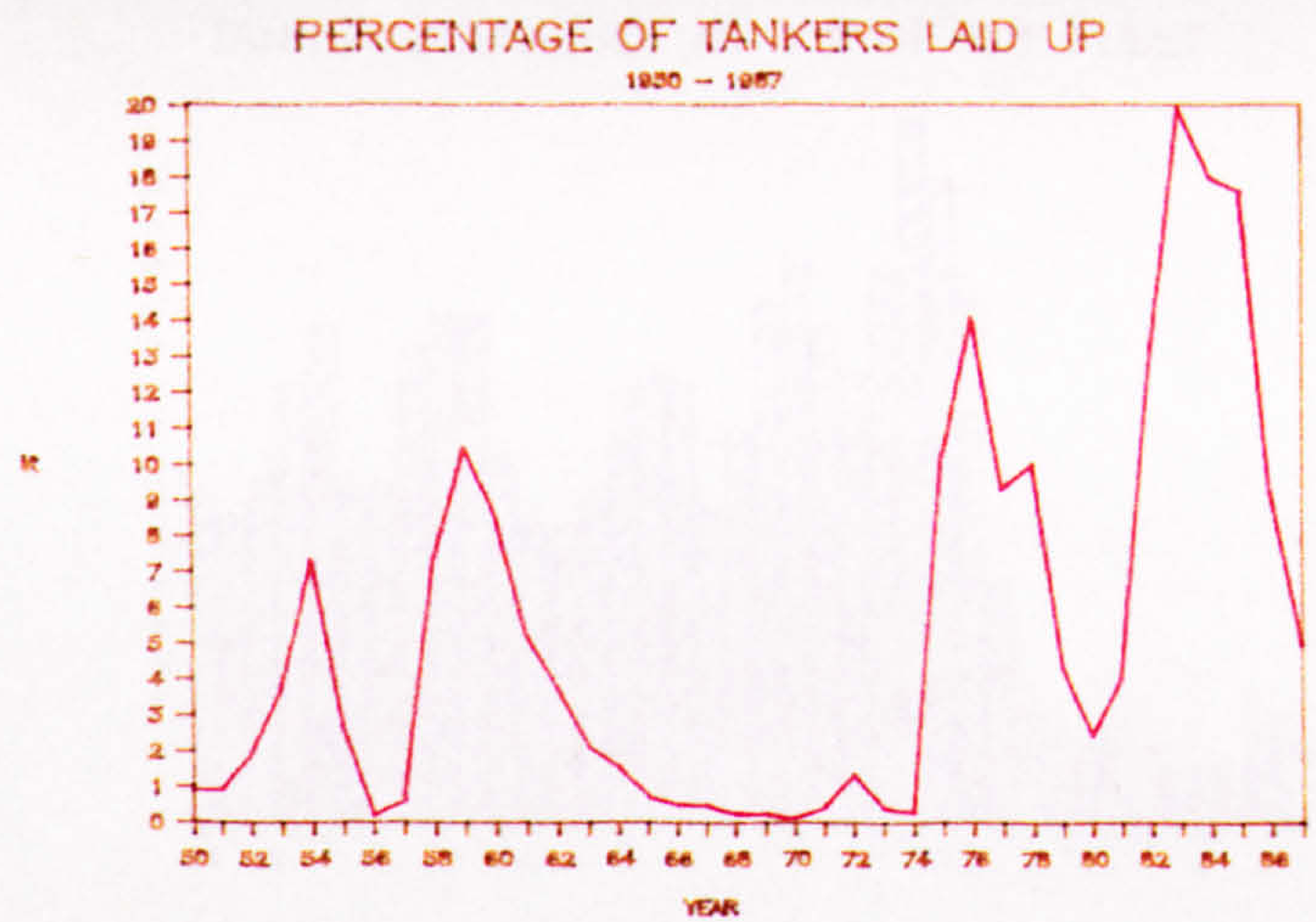

FIG. 1.60

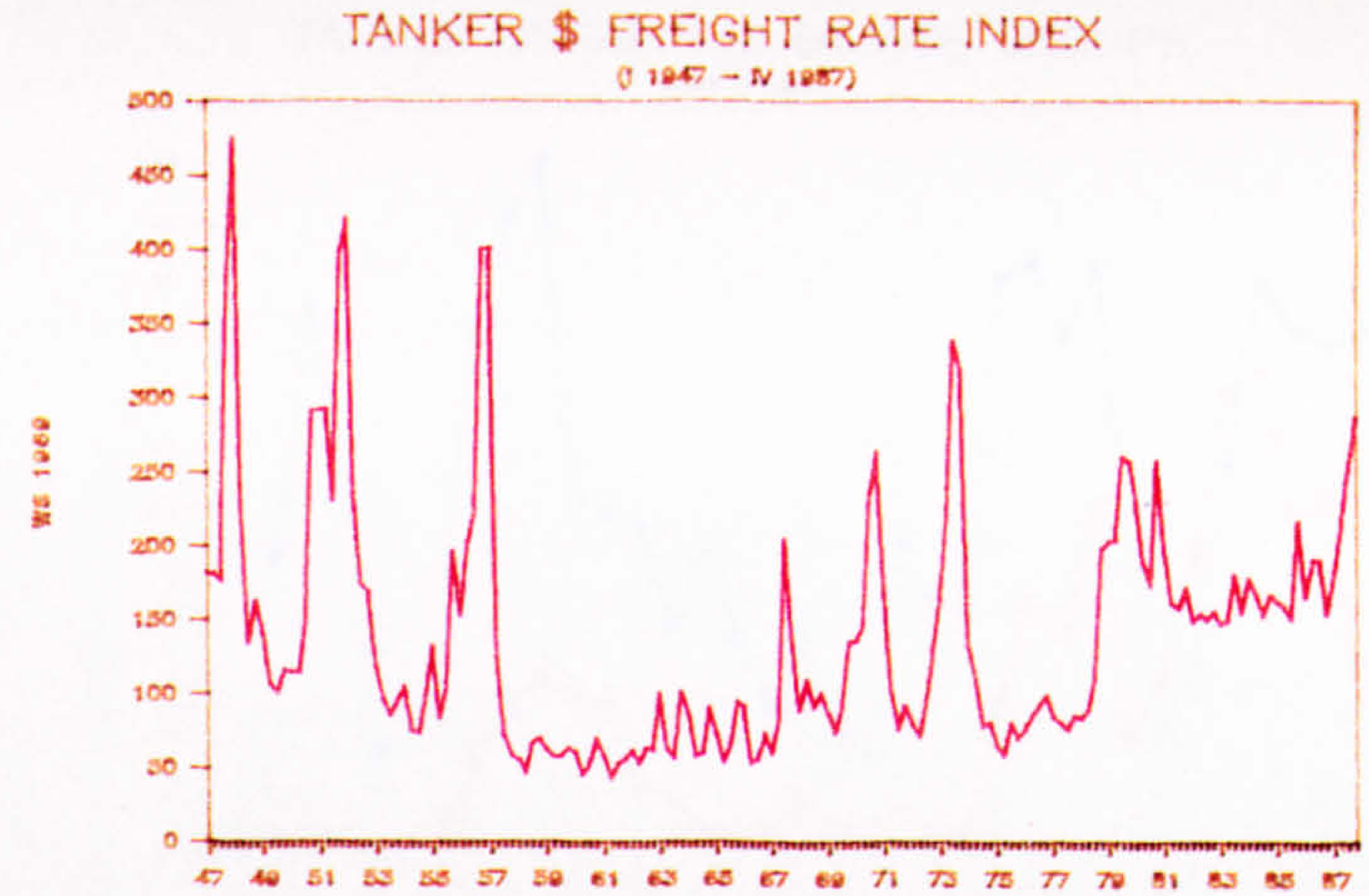

FIG. 1.61

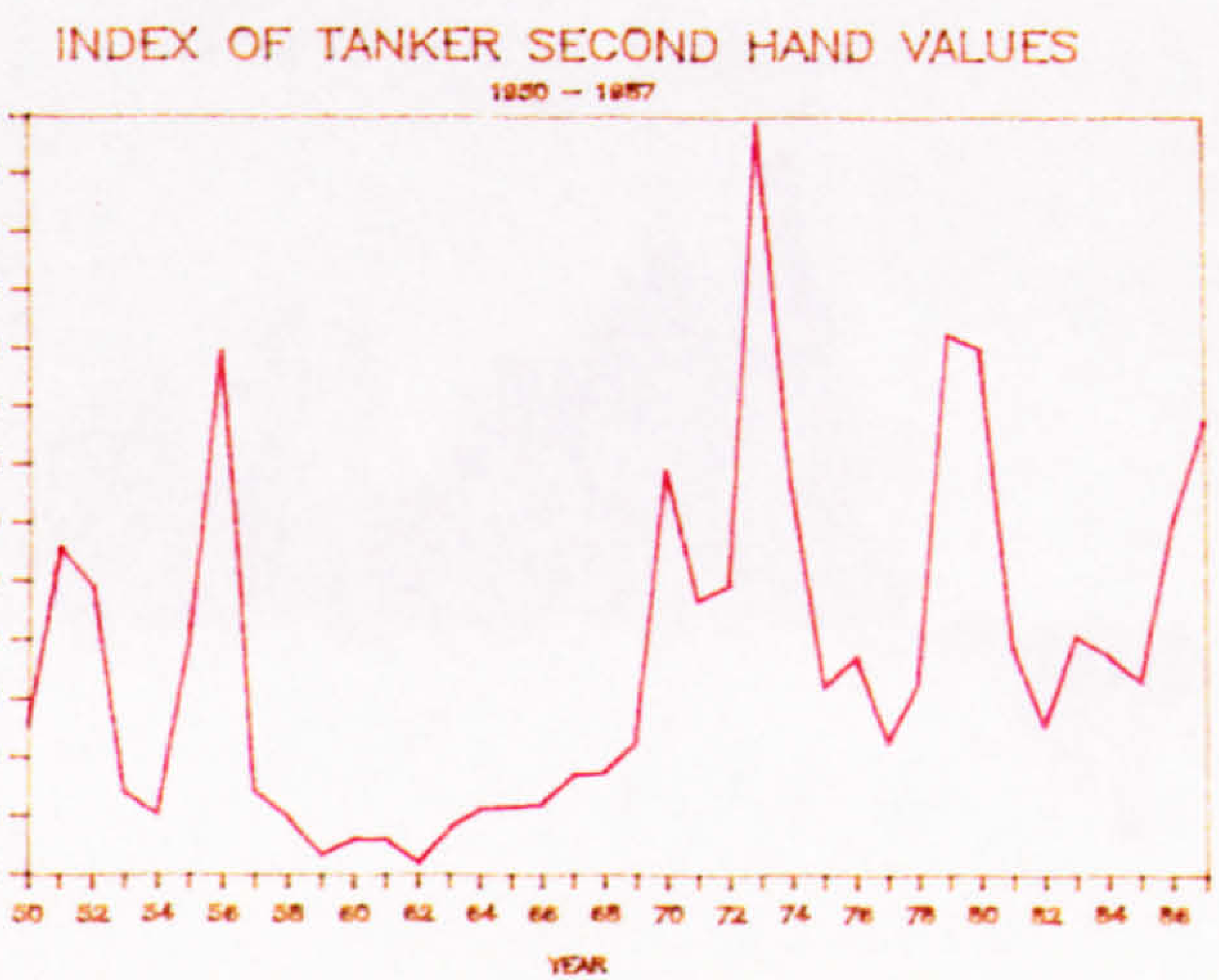

FIG. 1.62

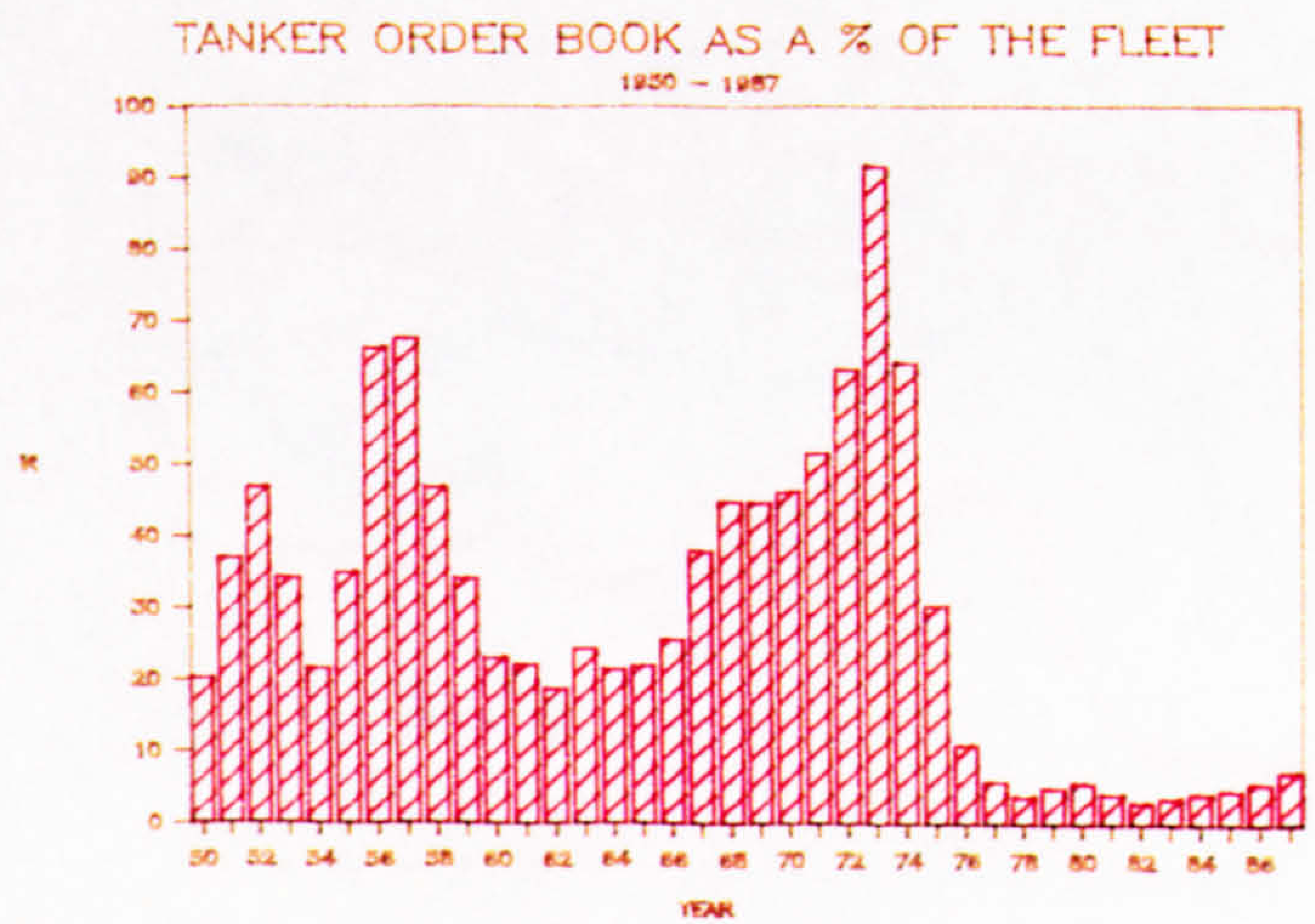

FIG. 1.63

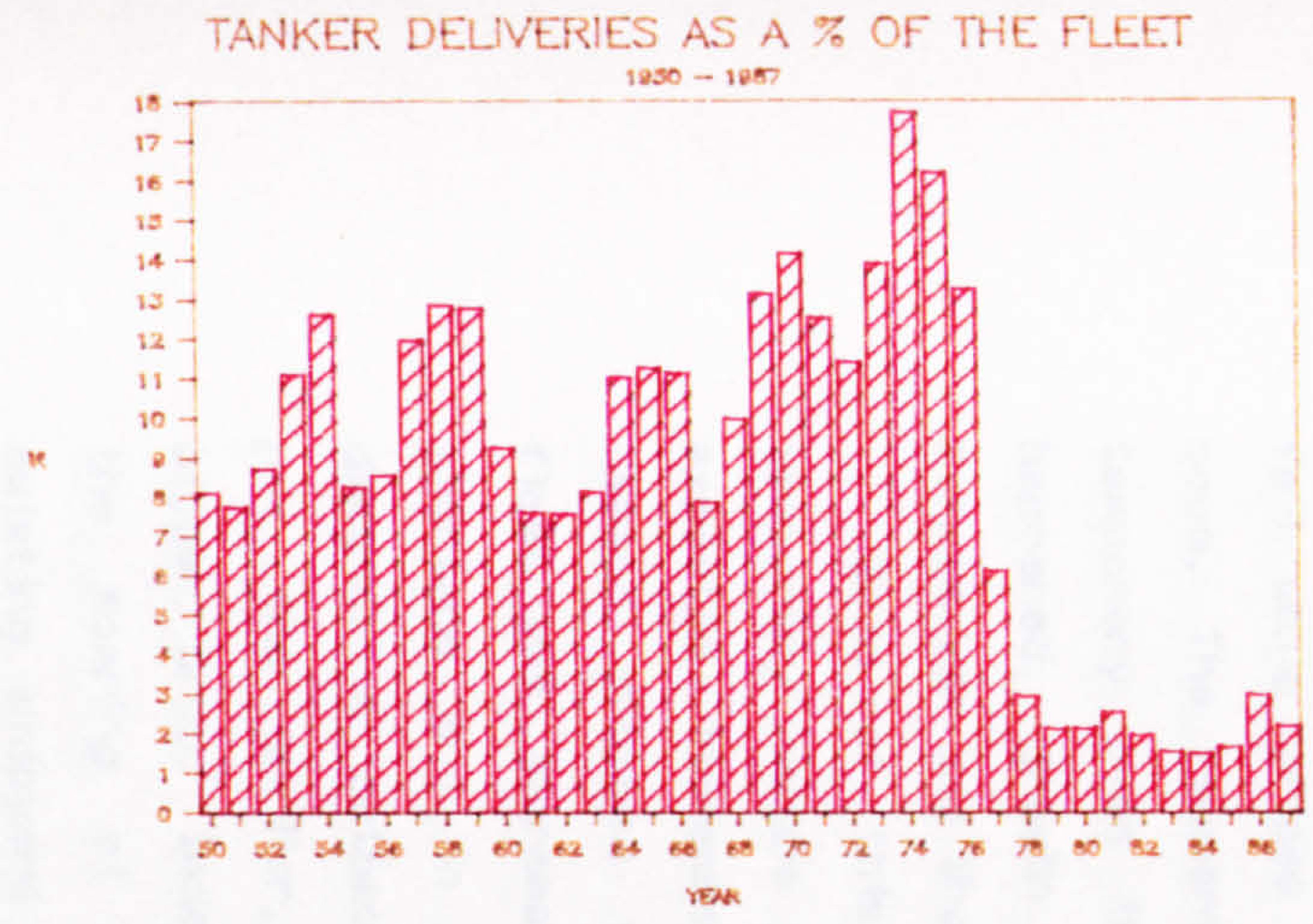

FIG. 1.64

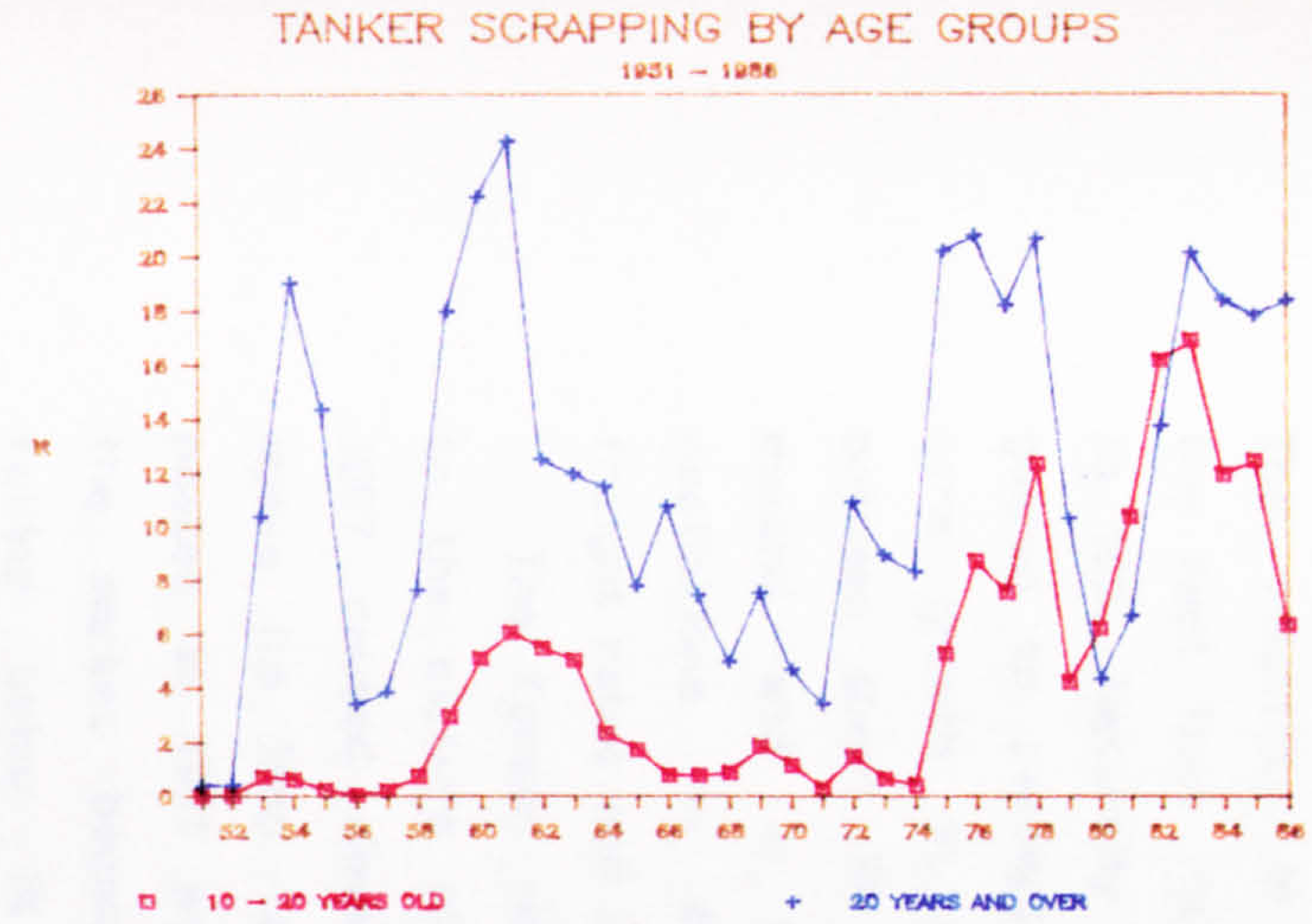

FIG. 1.65

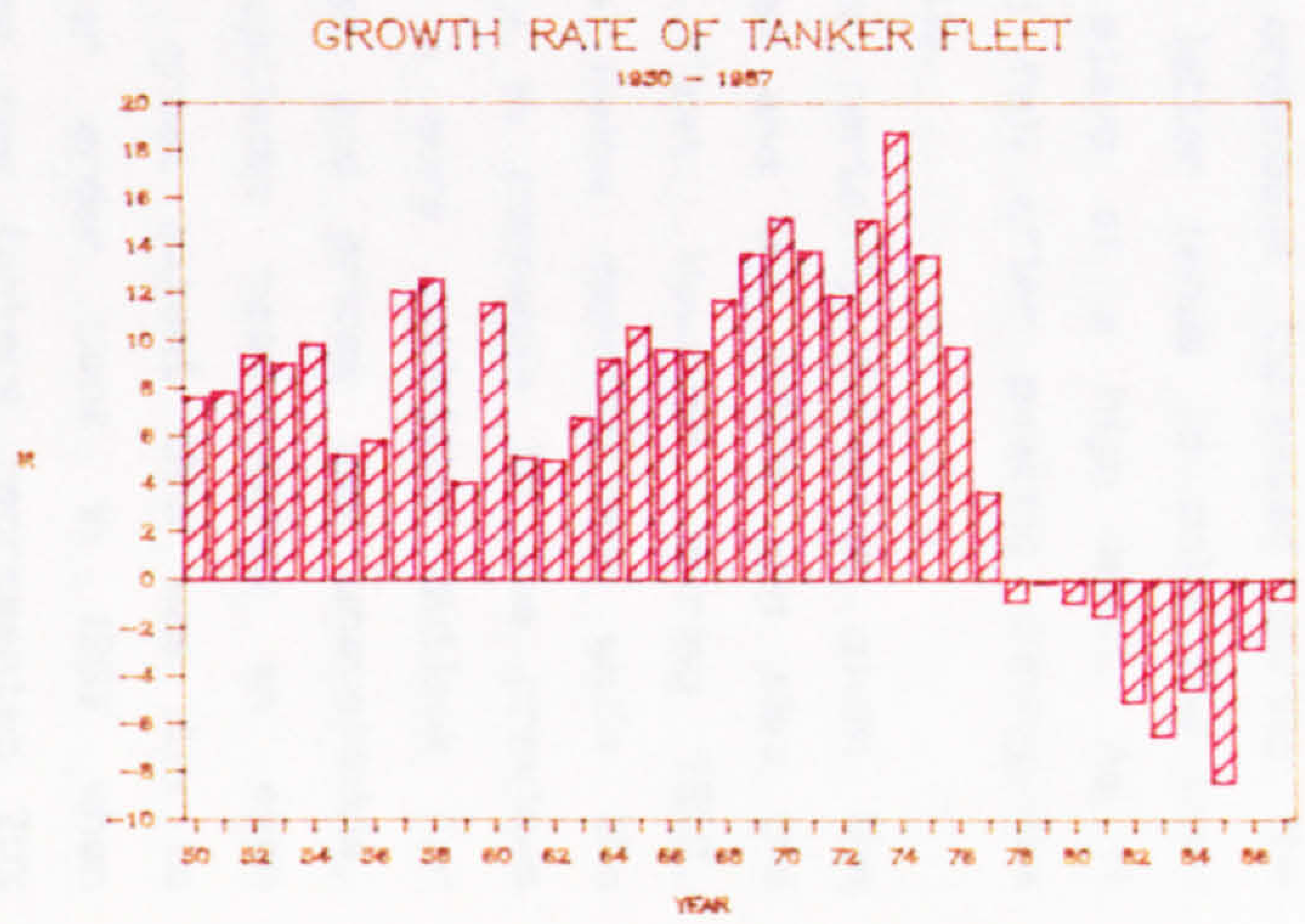

FIG. 1.66

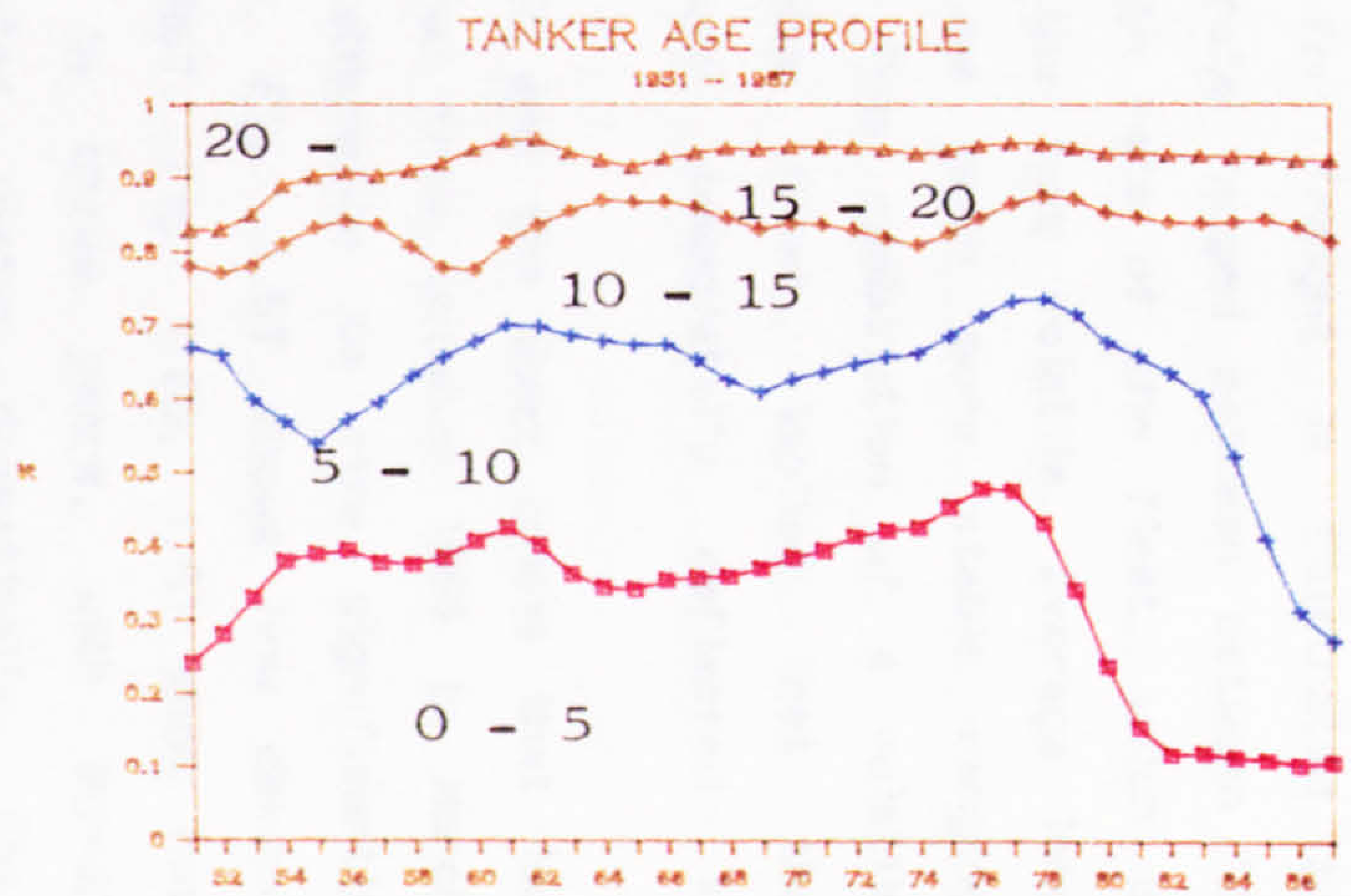

FIG. 1.67

closer to that of demand. However the solid growth in demand was not evenly distributed throughout these years. The volatility in demand for freight is illustrated by the fact that its growth rate ranged between between 3% to 15%. Naturally the growth rate of the fleet, which is geared to perceptions of the less volatile, average long term growth in demand, was much more stable ranging between about 5% to 10%. This combination of a volatile demand and a more stable fleet, implied that the oscilations in demand were immediatelly reflected in freight rates and lay-up.

The Korean war of 1951 and the Suez crisis that led to the closure of the canal from October 1956 to March 1957 caused demand for shipments to rise significantly above its long term trend. Fig. 1.57 shows how demand peaked in 1951 and 1955-1957. Fig. 1.60, 1.61 show how the market became tight in those years, with lay-up falling below 1% and rates rising dramatically. Fig. 1.62, 1.63, 1.65 show the response of prices, shipbuilding and scrapping which not only reflected short term developments but also long term views. Scrapping fell while prices and the orderbook increased during the boom. The response in the latter tends to make the boom temporary even if demand stays at a high level. As it happened, growth in demand fell after peaking during the Korean War and the Suez crisis.

Some of this drop was certainly foreseen given the temporary nature of the war and the crisis and also the expected increase in the fleet. However, during 1958, demand dropped very much below expectations while the fleet was increasing rapidly in response to the previous shortage and in line with a more optimistic outlook for demand. A setback in rates and prices was unavoidable, but the earlier, false optimism necessitated an even bigger drop. Indeed, to a great extent this was due to the soaring of the tanker order book in 1957 when existing shipyard orders for new tankers represented 70% of the existing fleet. This led to a subsequent flooding of the market with new ships, while at the same time the

Suez Canal was reopened and demand dropped significantly.

Thus during the 6 year period, from 1958 to 1963, the market was very depressed and occasionally rates were not sufficient to cover the operating costs let alone the capital costs. As a result of the drop in demand and the irreversible increase in the fleet, lay-up rose quickly to over 10% with the real surplus being even higher because of additional slow steaming. Rates naturally fell. Prices also fell reflecting the immediate outlook but also the longer term fundamentals and prospects. Even though the drop in values was expected to hit shipbuilding (Fig. 1.63, 1.64) and increase scrapping (Fig. 1.65) as it actually did, this could not have led to a significant improvement for some time. This was partly because of the size of the initial surplus.

Moreover, this was a period when a series of innovations in shipbuilding led to a continuous increase in the size of tankers being built. In 1950 the average size of tankers on order was 19500 dwt rising to 26600 in 1955, 42000 in 1960, 51100 in 1965, 116300 in 1970 and peaking to 145800 in 1973. These new ships, by virtue of their size and the associated economies of scale in constructing and operating them, could make good profits at low rates and were cheaper to build. The former tended to increase the demand for those ships while the latter increased the supply of newbuildings. Thus the fleet could now grow, even at rates which where uneconomic to build the older and smaller ship types. This tended to prolong the depression and to push down the equilibrium rates and the prices of the existing smaller ship types.

But the long term growth rate remained strong enough so by the mid sixties the surplus had been absorbed and thus followed a prosperous decade for shipowners. The growth rate in demand, which fell to below 3% in 1958, followed an upward trend in the following 5 years averaging at 6% p.a.. This, together with the depressed prices which restrained the increase in the size of the fleet, helped to absorb a significant amount of the initial surplus and of the newbuildings delivered. By

1963 lay-up had fallen to around 2%. As a result, rates began to oscillate around a higher level from 1963 onwards. This was also due to a recovery in the growth rate of demand which averaged out at 10.8% during the period 1963 to 1966. Prices and shipbuilding responded positively while scrapping fell.

Two external events took place during the second phase which although initially they had a small effect on the industry, they subsequently proved to have considerable long term implications. These were the 1959 decision of the US government to impose a quota on imports and the initiative of the producing countries that led to the formation of OPEC. According to the quota the proportion of future imports to the US was frozen to the 1959 level which was 4% of the domestic consumption. This was meant to protect the domestic economy from becoming dependent on unreliable foreign production. At that time Middle East and African production was rising rapidly and needed an outlet on the world markets of which the US was an important element. The producers correctly saw this action as a direct attack on their export revenues. With the door on the US market shut, their supply to the rest of the world increased and prices dropped. To stop the weakening of their oil prices and strengthen their negotiating position against the oil companies the Organization of Petroleum Exporting Countries was formed. Ample Middle East supplies depressed the world price of oil and led to rapid increases in demand and increasing share for OPEC production.

The 1967 to 1973 phase was undoubtedly the most profitable one of the whole post war period. The fundamental factors that contributed to this were many. Most important of all, was of course, the extreme increase in the growth rate of demand for shipments. Indeed with the closure of the Suez Canal which lasted from 1967 up to 1975, the growth rate in demand rose to record levels. During this latter phase of the pre OPEC era, the previous post war record of 15% growth in demand, was exceeded in almost every year!

In turn, the three main factors behind these solid growth rates, were the closure of the Suez Canal which lasted from 1967 up to 1975, the strong increase in world oil consumption/production and trade activity, and finally the even faster increase in the Middle East long haul exports to Japan, Europe and later on USA. Because of the closure of the canal, the latter had to be routed round Africa in order to reach their destination. The dramatic increase in the growth rate of demand and the part of it attributed to the increase in the average length of haul are shown on Fig. 1.56 and 1.57. Ironically, the increasing dependence of the US on Middle East oil, was largely due to her 1959 import quota. The quota restricted the supply of oil to the US market and raised the domestic price. This created the incentive to explore and develop local reserves which were then depleted rapidly. By 1970 local consumption was growing much faster than production, thus requiring more imports from the Middle East.

From 1966 to 1973, demand grew at an average rate of 17.4% p.a while the fleet only managed to grow at a rate of just 12.1% in spite of full shipyard capacity utilization and minimal scrapping. Other factors operating through the supply side of the market, also strongly contributed to an improvement in market conditions. Over this period we observe a real increase in metal and bunker prices, both of which had a positive effect on the market. The former restrains the increase in the fleet by reducing the supply of new ships and expanding the demand for scrap. The latter restrains the supply in the freight market, thus directly raising rates. The inflationary environment also led to at least a nominal increase in rates and values. The real yield on capital fell, further increasing the demand and prices of real assets such as ships. The growth rate of dry cargo shipments was also running at record levels, absorbing a significant amount of shipyard capacity and restraining the increase in the tanker fleet. Some of these developments were unexpected and thus the growth rate of the fleet was, at least initially, restrained by this early relative pessimism.

Each of these factors on its own had a positive effect which would have been much smaller under normal market conditions. However, when all other factors tend to push in the same direction, the incremental effect of an additional positive exogenous impulse is multiplied considerably. Further tightening of an already tight market, has significant effects on rates. In contrast it would only absorb lay-up and fail to move rates significantly if it came at a time when the market was slack. This tendency of mutual reinforcement of the positive effects of each external impulse, intensified the final impact of these developments.

Fig. 1.59 shows that the market became extremely tight during this period as a result of the above mentioned movements in the underlying fundamentals. Random but partly unavoidable explosions in rates and prices occurred during those years when demand grew above its trend level. This was a period when a series of demand-related surprises, coming at a time when the market was tight, helped to push rates upwards repeatedly. The first came in 1967 when the unexpected closure of the Suez Canal led to a freight market shortage. The second came in 1970 with the closure of the Tapline which necessitated a diversion of Saudi Arabian exports to Europe from the short haul pipeline route - which linked the Persian Gulf with the Mediterranean - to the long haul Persian Gulf/Western Europe via Cape route. The third and strongest increase came in 1973 when the general increase in the volume of shipments together with the increase in distances associated with the rapid expansion of US long haul imports, led to a further tightening of the freight market.

Tanker freight rates soared reaching Worldscale 280. At such a rate a 210000 dwt VLCC would make a profit of $5 million from one voyage lasting 70 days. The price of this ship in early 70's would have been $30 million implying that the vessel could have been repaid in just 14 months. The expectation of a further rapid increase in US imports from the Middle East and the psychological boost from a continuously strong freight market led to spectacular speculative increases in values with prices of VLCC's reaching $65 million. Parallel to that the 1973 order book expanded to a level which represented round about 90% of the existing fleet!

Viewed within a larger time framework, the whole 1950 to 1973 period was one of very high growth rate in demand for tankers, which averaged out at a level of 11.9%. In order for this demand to be satisfied it was necessary for the fleet to grow at the same rate on average. That could only happen if prices of tankers were on average high enough to create an incentive for shipbuilders to supply the newbuildings needed to expand the fleet at this high rate. In turn this necessitated a tight freight market balance so that rates and profits would be strong enough to earn a sufficient return on the high price. The tight freight market balance in turn implied that even a small unexpected increase in demand above its trend could easily lead to a booming market. Indeed during these years of high growth the market experienced a number of short-lived highly profitable booms during which owners could repay a big portion of their capital costs. Each of these booms was closely associated with individual external events that led to sudden spurts in demand which in turn resulted in a tighter freight market and an explosion in rates. These events included the Korean War in 1951, the Suez crisis in 1956-1957, the Arab-Israeli war and the second closure of the Suez Canal in 1967, the bombing of the Tapline in 1970 and the 1973 boom.

Because these events were of a great general importance, there is a danger of attributing the resultant improvements in freight rates solely to these events. There is thus a tendency to lose sight of the fact that probably the fundamental reason for the regularity and magnitude of these booms was that the *average* growth rate of demand remained high throughout the whole period and not because there were some years when this average was exceeded. It would be an exaggeration, but a useful one, to say that each event merely acted as a "straw that broke the camel's back" which had already been strained by solid long run growth rates. As already explained, the high growth rates necessitated a tight freight market on average. It was thus inevitable that there should have been some years of random spurts in demand above the average trend, tightening the market further and leading to significant increase in rates. Had the average growth rate in demand been lower, equilibrium would have been established around a less tight market, so that sudden spurts in demand would have led mainly to an absorption in lay-up and other surpluses rather than increases in rates. The occurence of these events did affect the timing of the booms but their frequency and magnitude was only affected to a smaller extent.

The post OPEC era

With the orderbook running at a very high level at end 1973, it was unavoidable and natural that some calm would eventually return to the market, after the last 7 stormy years of the pre-OPEC era. This would have happened even if actual growth in demand had moved in line with the high expectations of the early seventies. However instead of a soft landing towards a new long run equilibrium, the market fell from its sky high level, crashing into an abyss where it seemed there was no bottom to which prices and rates could sink. Investors were caught cold, as OPEC unexpectedly raised the price of oil in October 1973, which was the time when the tanker market and expectations were at their peak.

Up to that year the oil and tanker industry had experienced almost uninterupted growth for over a 100 years. In the last few years demand for tankers was growing at a particularly high average rate of over 15% p.a. With the rise of OPEC power the character of the oil market changed completely and unexpectedly. Actual developments in the tanker market also followed a completely different course from what had been expected.

OPEC's grievances had already begun to surface in 1970 when Libya nationalized BP's assets and raised its posted price from $2.17 to $2.485. Thanks to the steady growth in the demand for oil, OPEC's power had increased and the rest of its members soon followed Libya's example by also raising their prices. Subsequent events show that OPEC had already acquired the power to manipulate the oil industry by gaining a considerable market share. Possibly out of lack of knowledge, confidence and coordination this power had not been exploited yet. The Yom Kippur War between Egypt and Israel broke out in October 1973 and acted as a catalyst. In a moment of Arab unity, OPEC decided to use the oil weapon against USA. Production and exports were immediately reduced. The price of oil quadrapled and the world economic boom was suddenly over. One of the biggest economic disaster stories of those years was the collapse of the tanker market.

As a result of the cutback in long haul Middle East production, demand in the tanker market suddenly stagnated, remaining at around its 1973 level. This was at a time when the fleet was rising rapidly as a result of the 1973 ordering boom. The tankers on the massive orderbook were no longer needed. According to the terms of the contract, owners had to accept delivery of the newbuildings. From 1973 to 1979 demand grew at a rate of 0.5% p.a. whereas the fleet expanded at a rate of 7.2% p.a. wiping out all the gains in rates and freight market balance that had been achieved during the boom years of 1963 to 1973. The surplus became so large and the outlook for demand was so poor that the market was bound to be depressed for at least a decade. Overnight, VLCC values fell by $20 million. A 210000 dwt VLCC which in 1973 would have been ordered for $47 million, would be worth just $5 million in 1977. Parallel to the drop in oil trade, there was a drop in the average lenght of haul which did not just reflect the cutback in the supply of long haul OPEC oil. Non-OPEC short haul reserves which had been uneconomic to exploit at the pre 1972 oil price level, now became profitable. Increasing supply came forward from short haul producing areas to fill the gap that the restraint in long haul OPEC production was creating, thereby further reducing the average length of haul.

Scrapping rose to high levels during the late seventies and the orderbook evaporated as soon as the pre-1974 orders had been delivered. There was just no way that new tankers could be built without considerable loss to the builder, at prices which would have been acceptable to investors. The latter were extremely depressed as the huge surplus was not expected to be eliminated for at least a decade, even after taking into account the fact that the low values would stimulate scrapping and depress shipbuilding that could eventually lead to a market recovery.

In 1979 the market made a partial recovery as the higher bunker prices associated with the doubling of oil prices and other exogenous fleet inefficiencies led to a freight market shortage. This short lived boom however was followed by a new depression which was even more severe than the previous one. The determination of the cartel to maintain the price at a high level, at a time when this very price was causing a contraction in demand and an expansion in non-OPEC supply, necessitated increasing cutbacks in OPEC long haul production. As a result, demand fell by a devastating 50% during the 1980 to 1985 period which translates to an annual rate of decline of 15% p.a. Freight rates, profits, prices and shipbuilding hit all time lows, while scrapping reached an all time high. Values of 10 year old VLCC's collapsed to scrap price levels. Lay-up rose to 20% of the fleet with the real surplus being as much as 50% according to some estimates. Scrapping boomed reaching the extremely high rate of 7% of the fleet. The orderbook remained extremely depressed. Profitability in the freight market was persistently negative.

OPEC's power to manipulate prices however is not unlimited. Excessive use of that power can seriously weaken its ability to control the industry in the long run. This is because demand for OPEC oil - which is defined as the difference between total demand and non-OPEC supply - is much more elastic in the long run than in the short run. The high oil price creates an incentive for non-OPEC members to explore for new reserves thereby expanding supply. In addition the higher energy prices induces an increase in the supply of coal, nuclear and other substitutes for oil. At the same time capital goods are designed or converted so as to be able to utilize these relatively cheaper forms of energy. Thus, the demand for OPEC oil falls both because non-OPEC supply rises and because total demand for oil is falling. The cartel is then faced with two alternatives. It can either choose to maintain the price of oil at the cost of accepting increasing cutbacks in its own production and eventually this has a negative effect on profits. Alternatively it has the option to gain market share by increasing production which however will lead to a significant drop in the price as the extra output cannot otherwise be absorbed since in the short run demand is inelastic. This also has a negative effect on profits. Both alternatives therefore imply a short term reduction in profits but have different long term implications. The second option causes, through the lower price, a contraction in non-OPEC exploration and future production and in addition a gradual switch back to oil. This has positive long term implications about the ability of the cartel to raise the price again with little sacrifice on output.

In 1986 the cartel opted for the second alternative, refusing to accept additional sacrifices in production and thus allowing the price to drop. The implications for the tanker market were considerable as long haul exports stabilized after 6 years of continuous devastating reductions. In the meantime the fleet had shrunk considerably but because of the size of the surplus this failed to have an impact on rates. More recently demand has recovered slightly from its very low level, as a result of OPEC's decision to expand its market share at the expense of allowing the price of oil to drop. Together with the 27% reduction in the fleet size that has gradually taken place over the period from 1979 to 1987, this has had a beneficial effect on rates. Second hand values have risen by an even higher amount on the anticipation of further improvements in rates. The large proportion of overaged tankers is expected to lead to increased scrapping that will strengthen the market. High shipbuilding costs will prevent the fleet from rising until there is a realistic chance of rates increasing to a level that will make profitable the construction of replacement tankers for both investor and the shipbuilder. This points towards a permanent increase in rates and prices. Over the short term, demand might very well begin to grow again; certainly it will not fall. However, the stronger the short term growth of OPEC output and tanker demand, the higher are the chances of OPEC repeating its behaviour of 1973/4 and 1978/9.

1.4 Shipping cycles

We have argued that the shipping industry is very volatile. During a typical shipping cycle, freight rates, values, shipbuilding, scrapping and thus the the growth rate of the fleet will exhibit wide fluctuations. These fluctuations are to a great extent stochastic, caused by events of a random nature such as wars, oil shocks, Canal closures etc. However one might also discern a more deterministic element in them. A very important feature of the cycle however is the tendency of the market to revert to a more 'normal' or stable situation, once a shock from the external environment has led to a temporarily large disturbance. It is partly because of this tendency, that the various cycles exhibit recurring patterns which are common to most of the historical episodes. We suggest that this pattern of the market adapting to external shocks is due to the immutable laws of economic behaviour that govern the behaviour of economic agents in the freight, second hand, shipbuilding and scrapping markets. This behaviour generates dynamic linkages between the freight and other shipping markets which induce these patterns. Insofar as the exogenous shocks that initiate the cycle are of a similar nature (e.g unexpected increases in the demand for freight) the various historical episodes can be expected to exhibit strong similarities provided the laws of motion of the system are stable.

In this section we shall take another look at the available historical data on freight rates, ship prices, shipbuilding and scrappings for the dry cargo and tanker sectors. The objective is to identify the various cyclical patterns by casual observation and minimal resort to preconceived theoretical views. In subsequent chapters we explore these issues more formally in terms of an econometric model that describes the rational behaviour of economic agents in the various sectors of the shipping market. We show that our proposed theoretical model is consistent with the data in the sense that it can reproduce the characteristic features of the typical shipping cycle when it is subjected to random shocks such as those that occur in practise.

Figures 1.68 - 1.72 show the history of dry cargo freight rates, ship prices, deliveries, scrapping and fleet growth rate over the last hundred years or so. Figures 1.73 - 1.76 show the history of tanker freight rates, deliveries, scrappings and fleet growth rate since the beginning of this century. Long run historical data on tanker ship prices is not available. These charts illustrate the high volatility of the industry and the various comovements of the endogenous variables over the cycle. Casual investigation of the long term charts 1.68 - 1.76 as well as Fig. 1.1 - 1.67 which focus on specific shorter periods suggest the following characteristics:

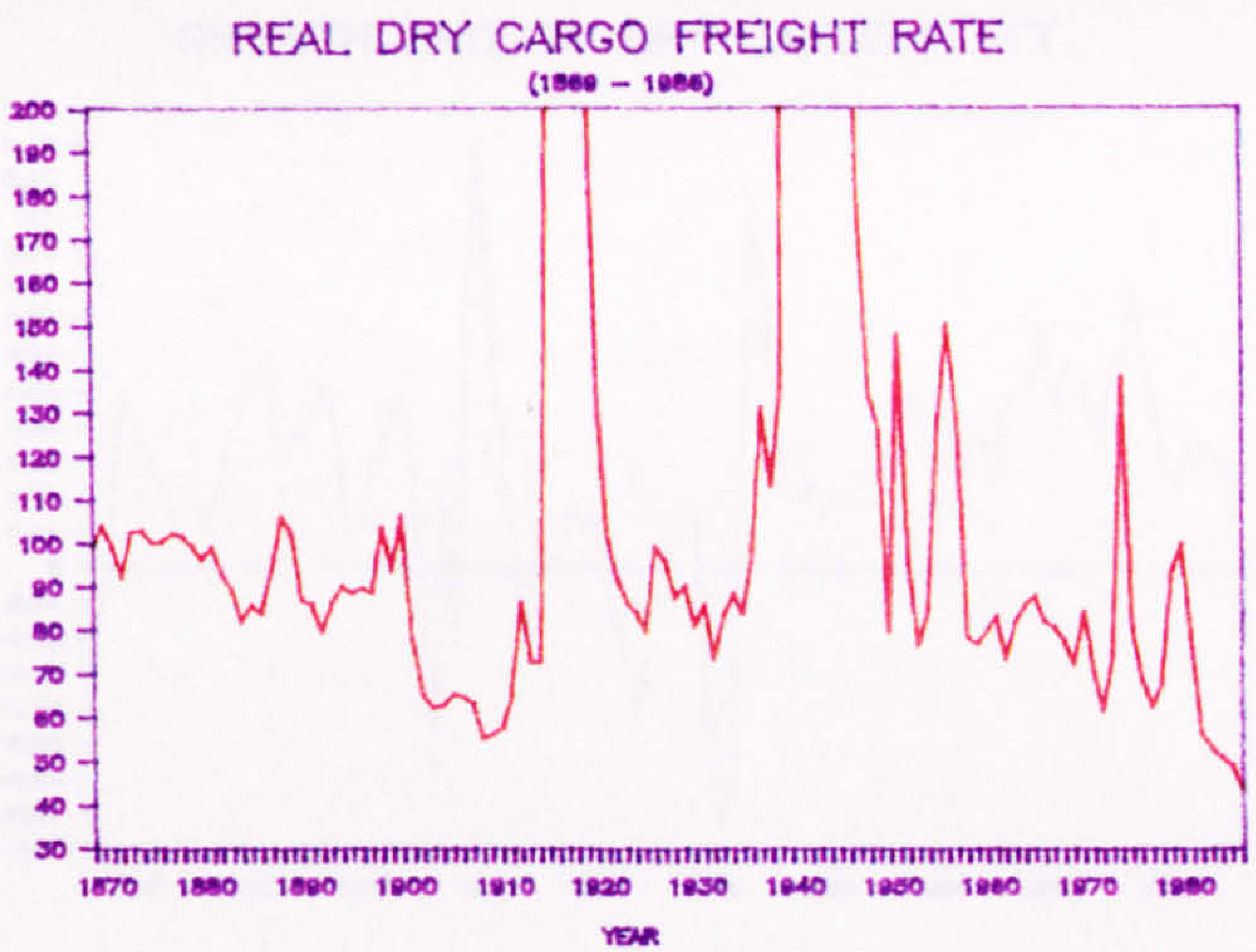

FIG. 1.68

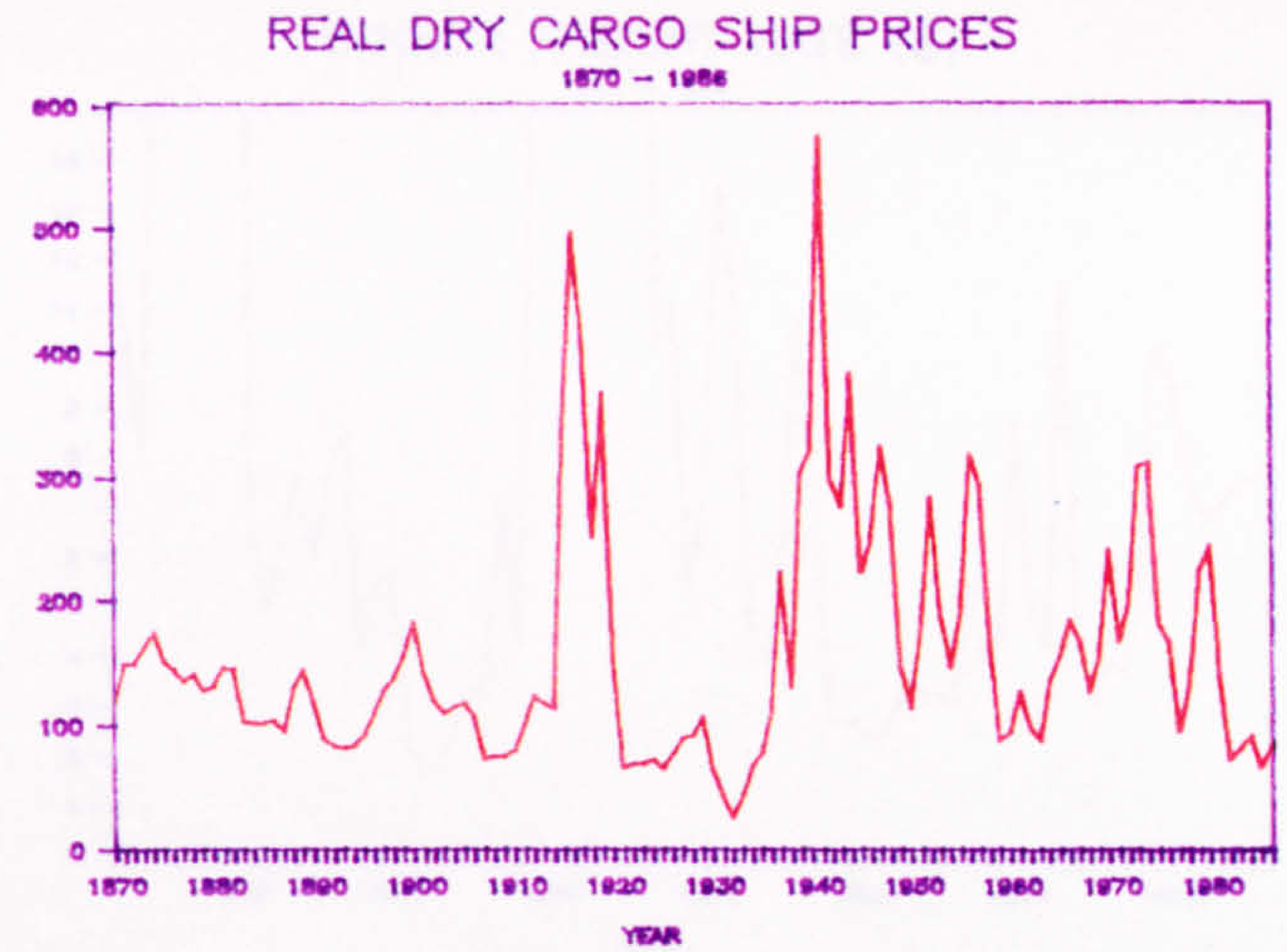

FIG. 1.69

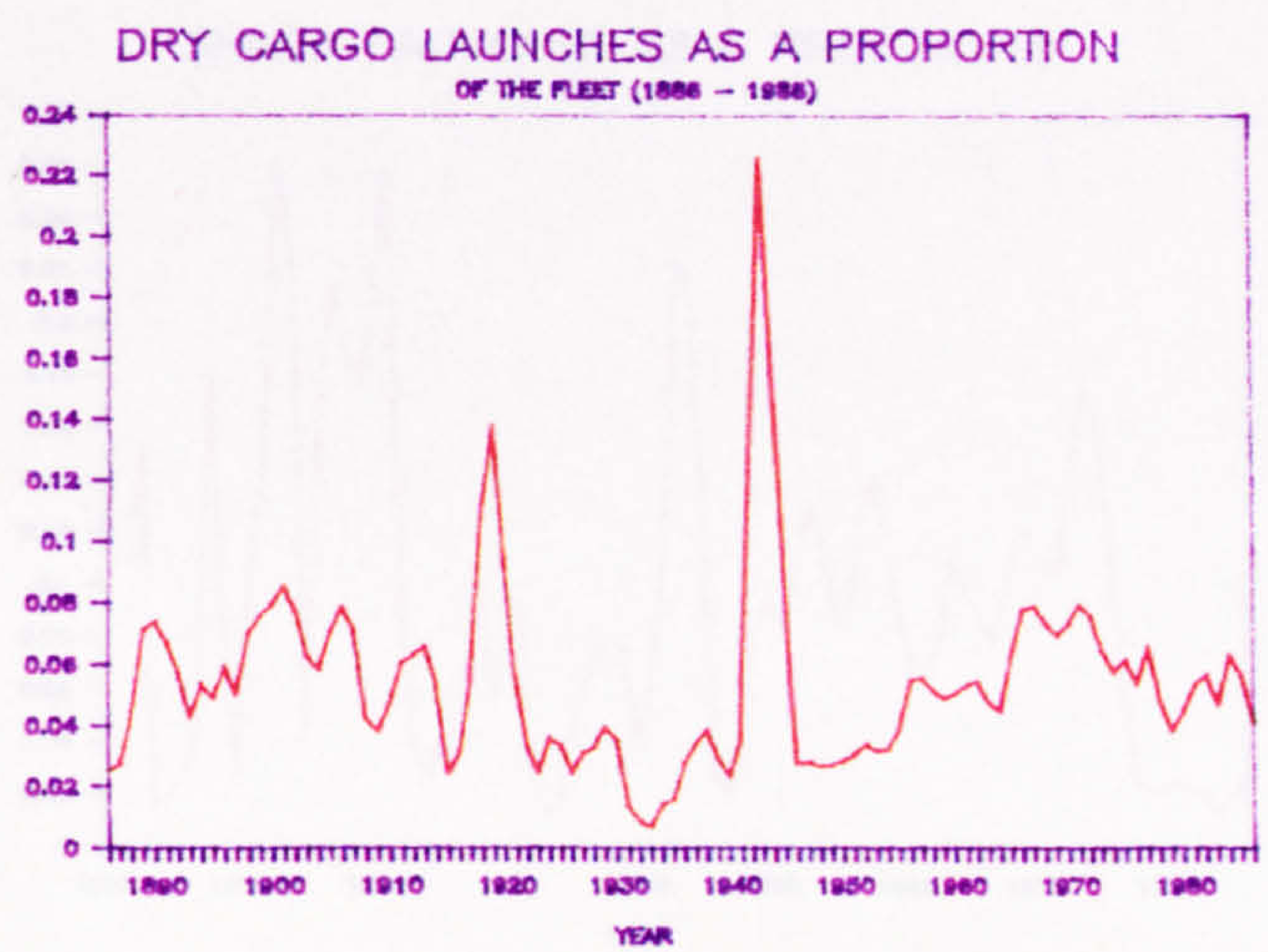

FIG. 1.70

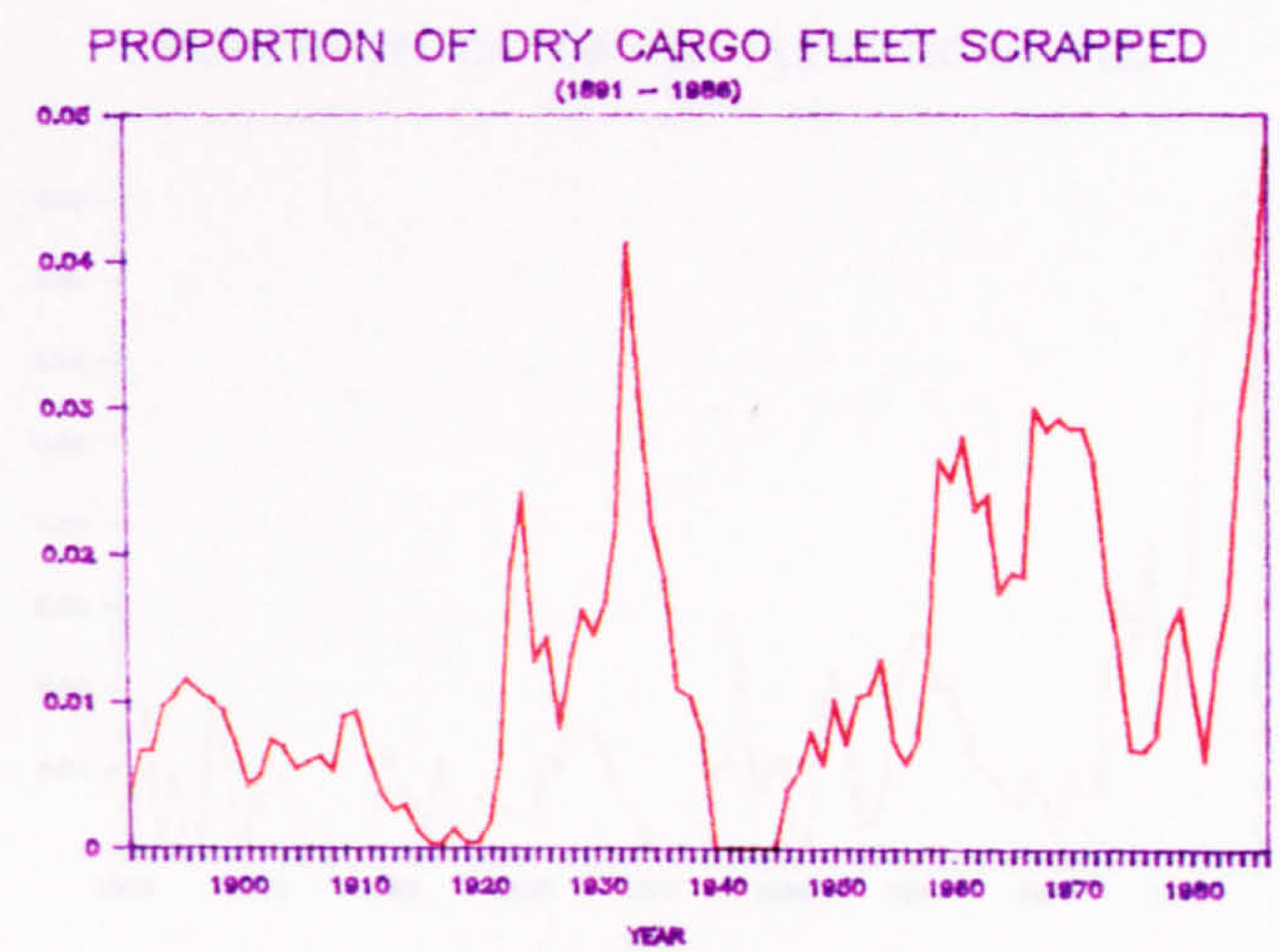

FIG. 1.71

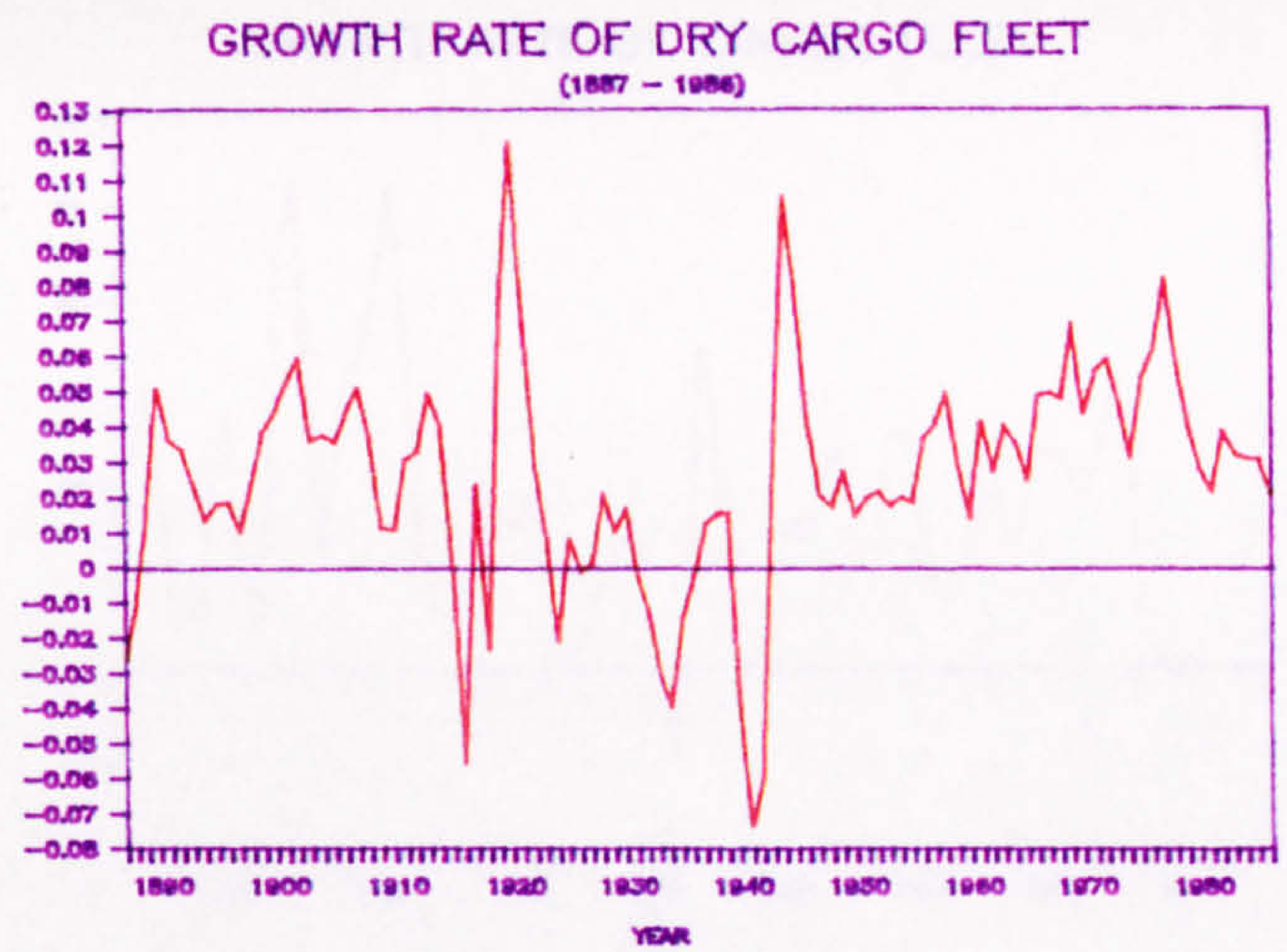

FIG. 1.72

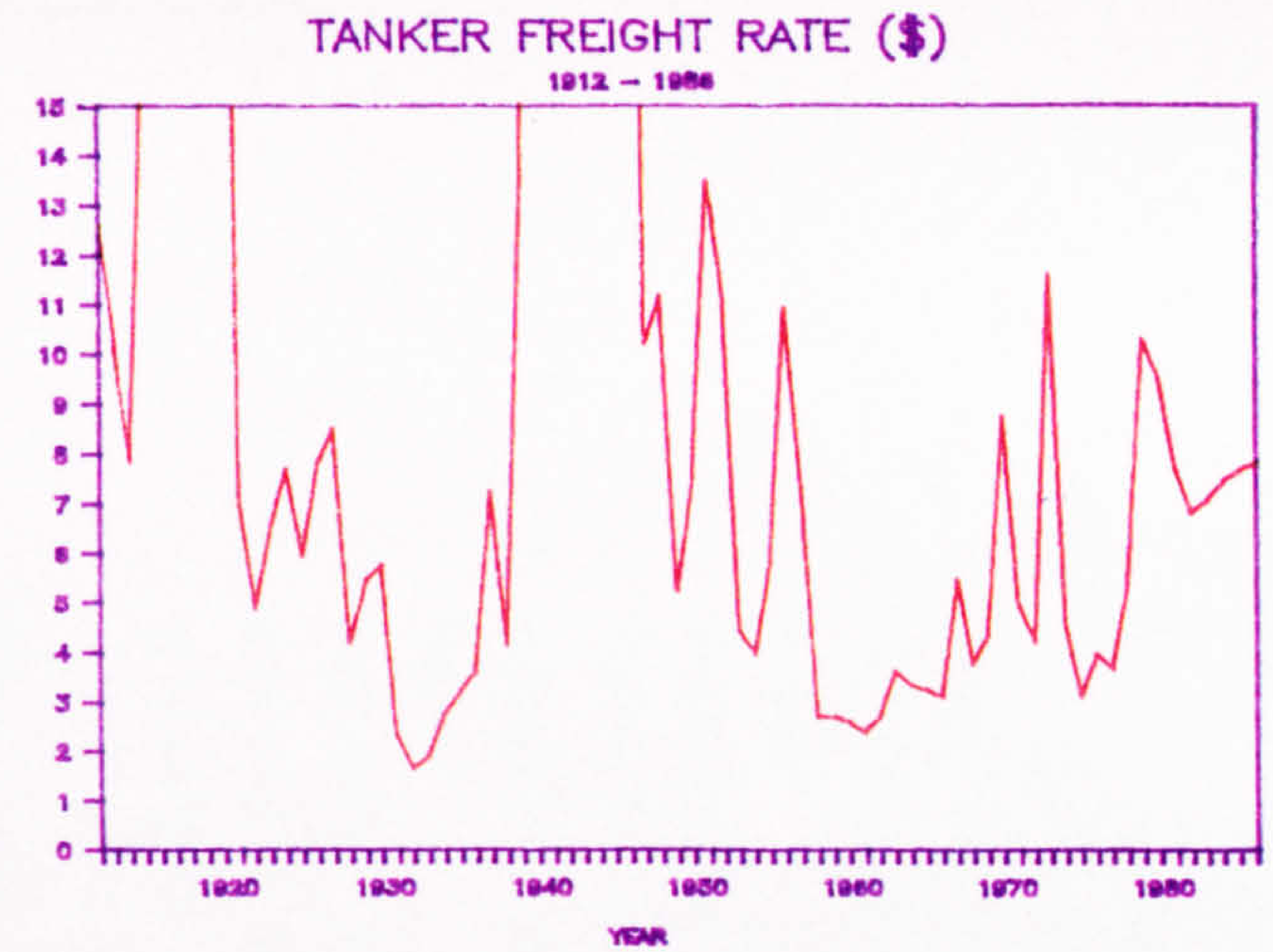

FIG. 1.73

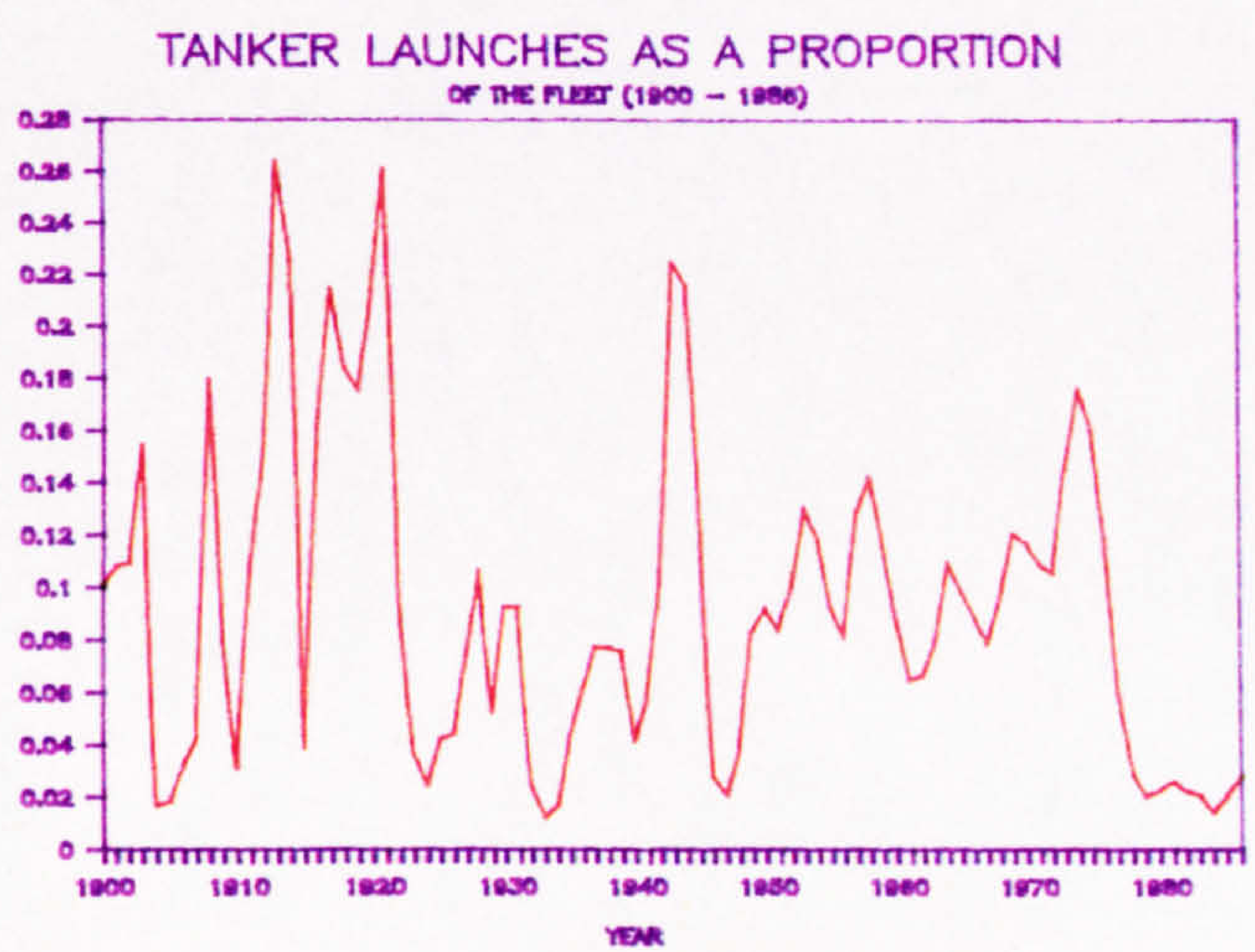

FIG. 1.74

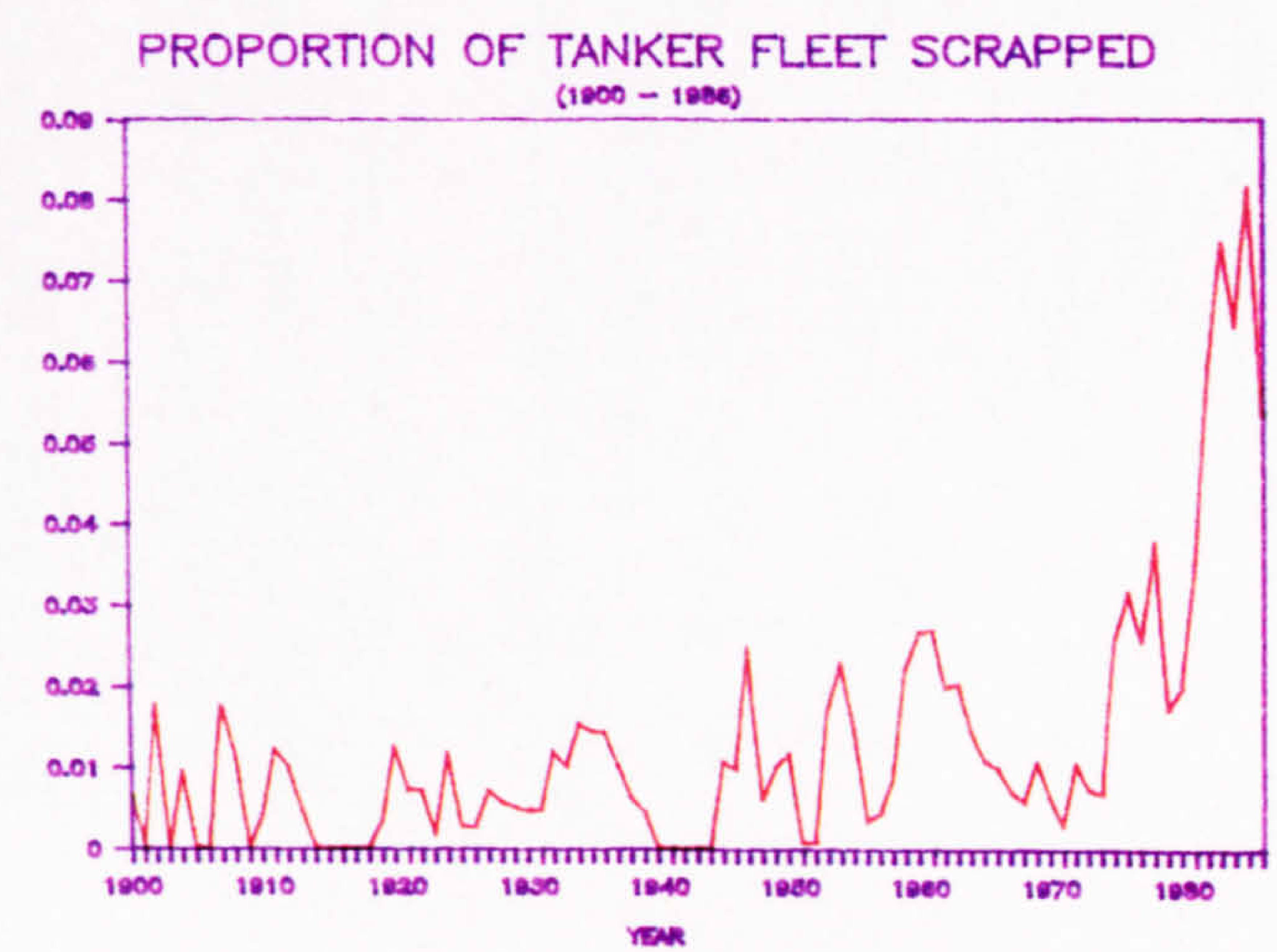

FIG. 1.75

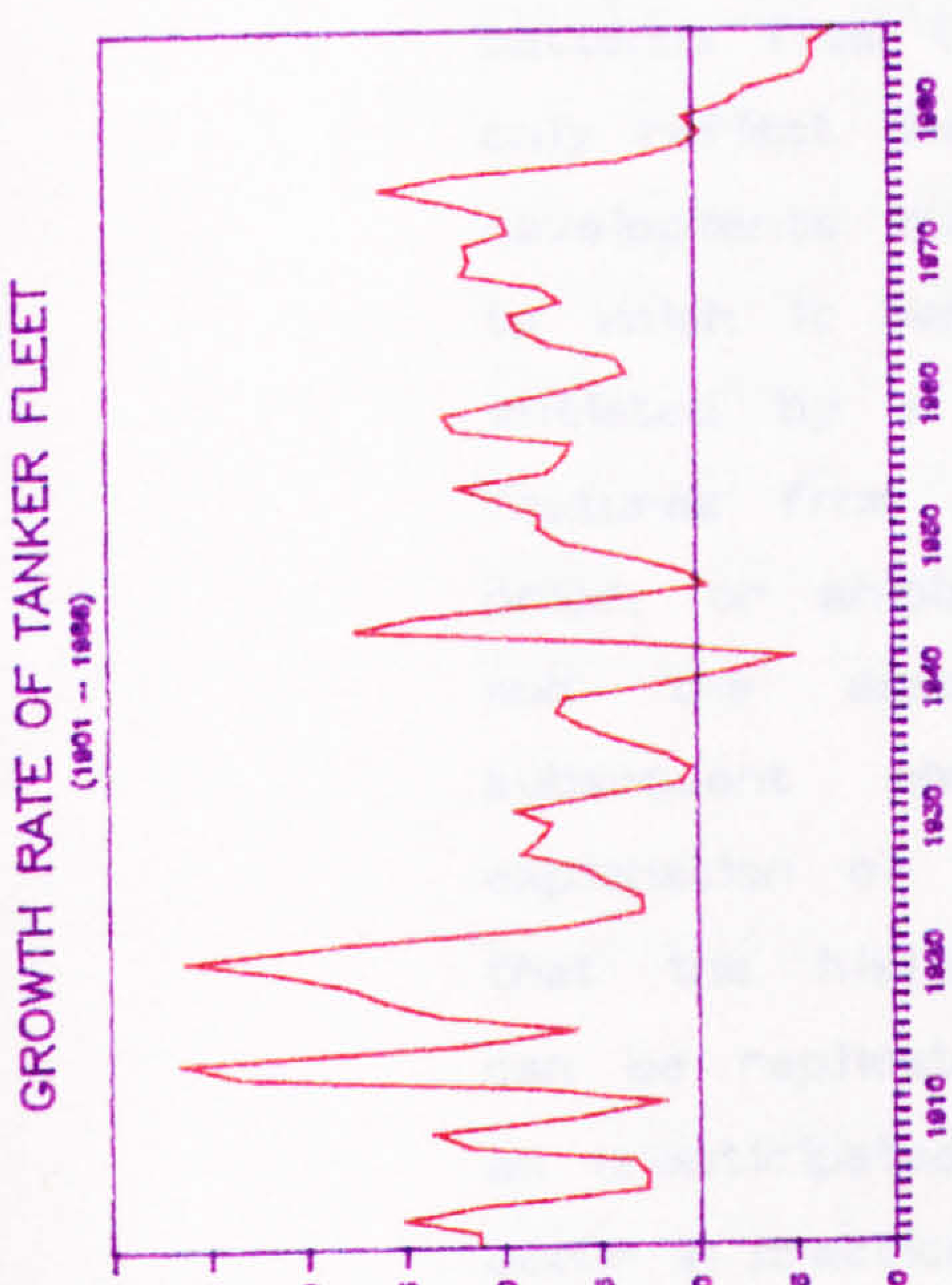

FIG. 1.76

- a) Freight market balance moves procyclically and in phase with rates
- b) Time charter rates move procyclically and in complete phase with freight rates
- c) Lay-up moves countercyclically and also in complete phase with rates
- d) Ship prices move procyclically and in phase with rates
- e) Shipbuilding output also moves procyclically but tends to lag behind rates by a year or so
- f) Scrapping moves countercyclically and in phase with rates
- g) The growth rate of the fleet which reflects the difference between shipbuilding and scrapping, moves procyclically but it also tends to lag behind rates

These are the characteristic features of a representative cycle. The duration of the cycle varies from one episode to the other. Of course, historical cycles also exhibit other individual patterns. It is conceivable that future cycles might exhibit different patterns from those of the past. Historical movements not only reflect the way that the market reacts to exogenous developments but also the nature of the external shocks to which it has been subjected. A cycle which has been initiated by a demand shock say, will exhibit different features from one that has been prompted by a bunker price, or shipbuilding cost, shock. The theoretical model and the associated econometric model presented in subsequent chapters aim to provide a theoretical explanation of why such patterns occur. It will be seen that the historical patterns of a representative cycle can be replicated by model simulation of the effects of an unanticipated demand shock, such as those that often occur in practice.

These simulations, which are presented in chapters 3,4,5,6 show that a permanent, unexpected increase in demand will, according to our model, lead to the following market response:

- a) There will be an immediate improvement in freight market balance at the time of the occurrence of the shock
- b) At the same time, time charter rates will increase, part of this increase being speculative
- c) Lay-up will fall immediately
- d) There will also be an immediate speculative increase in ship prices
- e) Shipbuilding will begin to recover and this will be translated into an increase in deliveries after a year or so
- f) Scrapping will also drop immediately
- g) The growth rate of the fleet will begin to recover immediately, as scrapping stops, with further increases occuring later on, when newbuildings come on stream

However, this short term turmoil, will be followed by a recessionary phase were the market will gradually tend to return to the path that it would have followed in the absence of the shock, until it is again perturbed by a new shock. Exactly the opposite movements would occur in the case where the market had been subjected to an unanticipated drop, rather than increase, in demand. These simulated movements do resemble the pattern exhibited by a representative shipping cycle. Thus we might say, that the model provides a theoretical explanation for the cyclical behaviour of the market.

*** Appendix : Construction of ship price indices*

This appendix describes how the ship price indices shown on Fig. 11, 26, 39, 51, 62, 70 have been constructed. The indices have been constructed from individual second hand sales of ships as reported by various brokers and shipping magazines over the years. About 5000 second hand sales spanning a time period of over a 100 years have been used in order to construct the index shown on Fig. 70. For each sale reported the following information is extracted:

a) The price *(P)* paid for the vessel
b) The size *(DWT)* of the vessel
c) The age *(A)* of the vessel
d) The year t of the sale

The calendar is rebased so that t runs from *1*, ... , *T*. Thus year 1 is the first year for which sales data have been collected while *T* is the last year. Other information regarding technological aspects of the ship have also been extracted. The sales have been grouped by year when the transaction took place. The aim is to use the data in order to construct a series for the general level of prices. The price $P_{i,t}$ of the i^{th} sale during a particular year t is assumed to reflect the general level of prices I_t during that year as well as vessel specific factors such as the size $S_{i,t}$ of the ship and its age $A_{i,t}$. A relationship of the following form is specified for the above variables:

$$P_{i,t} = I_t f(S_{i,t}, A_{i,t}) \tag{1}$$

This says that over time the price of a ship of a particular size and age moves in line with the general level of prices. For a given general level of values *I*, differences in prices of individual ships reflect differences in their sizes and ages. It is assumed that the functional form of $f(\cdot)$ is the following:

$$f(S_{i,t}, A_{i,t}) = S^{\beta}_{i,t} A^{\gamma}_{i,t} \tag{2}$$

Equation (1), (2) imply

$$P_{i,t} = I_t S^{\beta}_{i,t} A^{\gamma}_{i,t} \tag{3}$$

which in logarithms becomes

$$P_{i,t} = I_t + \beta S_{i,t} + \gamma A_{i,t} + u_{i,t} \qquad (4)$$

where all variables in (4) are redefined to represent logarithms of the original levels and where in addition an error term $u_{i,t}$ has been included to represent the effects on price of other random factors that have not been taken into account. We then stack the individual price, size and age data and we carry out the following regression

$$P_{i,t} = \sum_{\tau=1}^{T} I_\tau D_\tau + \beta S_{i,t} + \gamma A_{i,t} + u_{i,t} \qquad (5)$$

where D_τ , $\tau = 1, \ldots , T$ is a series of dummy vectors which take the value 1 if $\tau = t$ and the value 0 when $\tau \neq t$. The calculated coefficient $\hat{I}_\tau$ on the dummy variable D_τ is the estimated logarithm of the general level of prices.

CHAPTER 2

A SURVEY OF THE LITERATURE

This chapter reviews previous attempts to model the behaviour of shipping markets. Section 2 looks at the early pre-World War II efforts of Tinbergen and Koopmans. Sections 3-7 look at the post war efforts which have led to the construction of econometric models of the freight market and the markets for ships. The structure of these models is reviewed in some detail. The concluding section compares the various models and points out the similarity of freight market structures embodied in various models.

However, it also points out that the modelling of vessels' markets is a controversial issue which is illustrated by the disparity of second hand, newbuilding and scrapping market structures embodied in various model. This section also argues that, typically, work in this area has been theoretically flawed and inconsistent with rational behaviour.

2.1 Introduction

Our objective in this chapter is to review previous attempts to model various aspects of the market for shipping and to set the scene for our efforts. Indeed, the freight market was one of the very first areas of applied econometric analysis reflecting the development of econometrics in Holland under Tinbergen and Koopmans and Dutch interests in world shipping during the 1930s. However, despite this auspicious aspect of the freight market, applied econometrics has hardly flourished in the area of world shipping. Nevertheless, there have been several attempts to model world shipping markets either in whole or in part and these are the focus of attention in the present chapter.

At the outset we point out that freight markets have received most of the attention to the virtual exclusion of the markets in vessels. However, we argue that the freight and vessel markets are so interdependent that a proper understanding of the dynamics of the one cannot be achieved without an analysis of the other. It is also argued that the little work that has been done on the vessel market for newbuildings and second hand ships is theoretically flawed in two important respects. First, vessels have in general not been regarded as capital assets, which they obviously are. Secondly, the speculative aspect of the demand for new and second hand vessels has been either allocated a secondary role or at best it has been treated in a naive way. In contrast, in our own efforts, the full weight of capital theory is brought forward to bear upon the design of the model while speculation is accorded a primary role in terms of the theory of "Rational Expectations" upon which our proposed model is also based.

The pre World War II efforts

The early pre World War II efforts concentrated on modelling supply in the freight market. There was, by contrast, relatively little focus on the demand side of the market basically because of the enormous practical difficulties involved. To our knowledge, even until today, these difficulties have prevented the construction of a satisfactory simple empirical model of the demand for freight. Relatively little progress was also made on the markets for ships despite the availability of sufficiently good data. Empirical work on the freight market was undertaken by Tinbergen (1933), (1934) and Koopmans (1939). In another theoretical contribution, Tinbergen (1931) considered how an endogenous shipbuilding cycle can arise out of the interactions of the freight and ship markets.

Post World War II efforts

Since World War II there have been numerous contributions to the problem. Econometric studies have investigated supply and demand relationships in various shipping markets. Based on these, integrated mathematical models of the tanker or dry cargo markets such as Norship, Dynamo or those of Hawdon (1978) or Charemza and Gronicki (1981) have been constructed. Extremely disaggregated models of the freight market such as Martinet have also appeared.

2.2 The early efforts (Tinbergen and Koopmans)

We begin with the pioneering work of Tinbergen and Koopmans. Tinbergen (1934), in what is one of the earliest econometric applications, investigated the sensitivity of freight rates to changes in the level of demand q on the one hand, and to the factors affecting supply on the other. The latter include the level of tonnage K and the price of bunkers P_b. Other factors such as operating costs are also specified to influence rates but since these are more or less constant during the cycle in relation to other variables, their effect is treated as a constant. As in most models of the freight markets, Tinbergen considers demand to be perfectly inelastic with respect to freight rates. Supply on the other hand responds positively to freight rates and it will shift when changes in the size of the fleet or the price of fuel occur. An increase in the size of the fleet increases the supply of freight services q^s as measured in ton-miles. On the other hand an increase in the price of bunkers will cause supply at a given freight rate to contract as ships find that it is now more economical to slow-steam while some vessels might even move into lay-up. Thus supply is implicitly specified to be

$$q^s = K^{\alpha} Pb^{-\beta} F^{\gamma} \tag{1}$$

where one would expect α to be close to 1 while β and γ should be both positive. Tinbergen also implicitly assumes that freight rates move in order to set demand equal to supply.

$$q = q^s \tag{2}$$

The two expressions imply that the equilibrium freight rate can be written as a function of q, K, Pb. By substituting (1) into (2) and taking logarithms on both sides of the equation this relationship can be written as

$$F = e_1 q - e_2 K + e_3 Pb \tag{3}$$

where

$$\begin{aligned} e_1 &= 1/\gamma \\ e_2 &= \alpha/\gamma \\ e_3 &= \beta/\gamma \end{aligned} \tag{3'}$$

and where all variables are now in logarithms. Equation

(3) expresses the relationship between equilibrium freight rates and the level of demand, the size of the fleet and bunker prices. In fact Tinbergen does not explicitly specify equations (1) and (2) but only (3) in a slightly different way but which is equivalent to ours. However (1) and (2) are implicit in his writings. They are specified explicitly here in order to set out a uniform notation and framework that will facilitate comparison with other work including our own. Tinbergen then uses data for ton-miles, the size of the fleet, bunker prices and freight rates over the period 1870 - 1913 to estimate the unknown parameters of (3) by regression[1]. His empirical estimates are

$$F = 1.7q - 1.6K + 0.4P_b \tag{4}$$

"The formula", he concludes, "demonstrates the relative importance of the three factors: ... the demand index ... the supply index ... and ... the coal price on the calculated freight rate". This had actually been the purpose of the investigation namely to determine the sensitivity of freight rates to these three factors. We think however it is also useful to use (3') in order to relate the estimated coefficients of e_1, e_2, e_3 to the parameters of (1), since the latter can be conveniently interpreted as elasticities. Tinbergens' estimates imply the following values for α, β, γ:

$$\alpha = 0.94, \quad \beta = 0.23, \quad \gamma = 0.59$$

The estimated value for α, which is the elasticity of supply with respect to the fleet, is 0.94 which seems to be close to the theoretical value of 1. The coefficients for both β and γ are positive as expected a priori. The

[1] The regression is applied to the annual differences of the 5 year moving averages of the levels of the variables.

former indicates the elasticity of supply with respect to fuel prices and the latter the elasticity with respect to freight rates. It can be seen that supply is fairly inelastic both with respect to rates and bunker prices.

In another article which antedates his empirical work on freight rates, Tinbergen (1931) considered a theoretical model of the shipbuilding cycle. A dynamic equation for the evolution of the fleet is derived by considering several dynamic relationships between shipbuilding, freight rates and the fleet for given values of the exogenous variables. First, a larger fleet implies lower freight rates at a given point in time t because of the positive effects of an expansion in the fleet on supply. This is expressed by equation (5) below. The change in the fleet at time t (after allowing for scrapping and losses) is related to the amount of current deliveries which in turn are related to orders Q at time $t-\theta$ where θ is the lag between ordering and delivery. This relationship is expressed by equation (6), where $\dot{x}$ indicates the instantaneous rate of change of variable x. Thus equation (6) says that the rate of change of the fleet $\dot{K}(t)$ is proportional to orders of new ships at time $t-\theta$. Finally these orders are assumed to be positively related to prevailing freight rates as expressed by equation (7). This is because higher rates lead to optimism that increases the demand for orders.

$$F(t) = - \rho K(t) \tag{5}$$

$$\dot{K}(t) = Q(t-\theta) \tag{6}$$

$$Q(t-\theta) = \lambda F(t-\theta) \tag{7}$$

Various other variables should also be allowed of course to enter these equations. Shifting (5) backwards by θ time units and substituting this into (7) and the result into (6) we obtain (8) which is

$$\dot{K}(t) = -aK(t-\theta) \tag{8}$$

where

$$a = \lambda\rho$$

Tinbergen calls the parameter a as the intensity of reaction. It depends on the sensitivity of freight rates to the fleet and of orders to freight rates. Equation (8) is a differential equation which the author solves to determine the equilibrium time path of the fleet. It is found that the solution of (8) for plausible values of the parameters exhibits cyclical behaviour as represented by a mixture of sine waves. One of the sine waves has a period which is at least equal to 2ϑ and for plausible values of the parameter a it is greater than 4ϑ. For the most likely values of α and ϑ, the system exhibits an endogenous damping cycle with a periodicity of about 7.5 to 8.7 years. Tinbergen then uses this theoretical model in order to make two year ahead predictions of shipbuilding deliveries and finds that these are quite acceptable and can even sometimes foresee various turning points. He also carried out an ex ante twelve year forecast based on the theoretical model and initial conditions and finds that this also tracked actual developments quite well and even foresaw a turning point which lay about six years ahead.

Most of the subsequent models of the shipping markets incorporate a set of relationships such as (5), (6) and (7) which generate similar cyclical behaviour. Of course Tinbergen considered a rudimentary shipping cycle focusing on the endogenous interactions between rates, shipbuilding and the size of the fleet while keeping the exogenous variables out of the picture by treating them as constants. Existing econometric models of the shipping markets allow for a much richer set of instantaneous or lagged exogenous and endogenous influences. However the basic forces which generate the cyclical behaviour in such models are broadly similar to those explored by Tinbergen.

During the same period Koopmans (1939) investigated the behaviour of tanker freight rates. The main body of the book is an exhaustive theoretical analysis of the determinants of supply in the freight market supported by some statistical investigations. Other parts of the book deal with the demand side of the freight market but little attempt is made at modelling mathematically the demand for freight because of the complexity of the issue. Some attention is also given to the shipbuilding market but no additional theory other than that of Tinbergen is rigorously examined. The freight market section of the book is partly concerned with providing an explanation of why there seem to be periods of prosperity when tanker freight rates become extremely volatile fluctuating around a very high level while there are other longer periods of depression when rates are stable at a low level. The author attributes that to the interaction between an inelastic demand for ton-miles with a peculiarly shaped supply function. At a very low level of freight rates supply is extremely elastic so its shape is almost horizontal while at a high level of freight rates it becomes very inelastic taking up a vertical shape. When demand meets supply at the elastic region then even wide fluctuations in demand will have little impact on rates. On the other hand, when the inelastic demand crosses the supply function at its inelastic region then even small fluctuations in transportation requirements or the size of the fleet can lead to big changes in rates.

The elasticity of supply during periods of prosperity i.e when the fleet is highly utilized is estimated from semi-annual data covering the period from 1920 to early 1930s. He assumes that supply of ton-miles is directly proportional to the size of the fleet while the supply generated by a unit of capacity depends on the ratio of freight rates to an index of bunker prices and other operating costs. Taking into account that in equilibrium demand must equal supply, the following relationship between rates, fleet, demand and costs is specified

$$q = K(F/P_b)^{\gamma} \tag{9}$$

This is identical with specification (1) implicit in Tinbergen, however, here there are some a priori constraints imposed on the parameters and P_b should be reinterpreted as an index of both fuel and other costs and where, in addition, a time trend effect has been allowed. The parameter γ is estimated from the data and it is found to be equal to a value of about 0.15, suggesting that supply does indeed become very inelastic as lay-up falls.

2.3 Norship, An integrated model of the tanker and bulk carrier market

The Center for Applied Research of the Norwegian School of Economics and Business Administration has published a considerable volume of theoretical and empirical work on the shipping markets. These and other studies applied to post World War II data, have confirmed the results of Tinbergen and Koopmans regarding the elasticity of supply of freight services. In contrast to the supply side of the freight market where a considerable amount of empirical work has been undertaken, there have as yet been very few attempts at modelling the demand side of the market. This reflects the practical difficulties involved in such a study. To quote Koopmans (1939), "...a quantitative analysis of the demand factors of the tanker freight market is a task which far surpasses the limits imposed by practical considerations. ...It would imply an analysis of the conditions of supply and demand of oils in a large number of countries, and of the strategy of the world oil markets." Similar problems appear when the dry cargo demand for freight is modelled.

The demand for bulk services - Eriksen (1977)

One of the few studies of the possible influence of freight rates on demand is that of Eriksen (1977). He considers the pattern of seaborne trade for various individual dry bulk goods in terms of the seaborne trade matrix. The ij^{th} element of this matrix shows the quantity of goods transported by sea, from export area i to import area j. By multiplying the quantities transported in various routes by the distances involved the actual ton-mile demand can be derived. The actual average distance is then given by dividing the total ton-mile figure by the total volume of seaborne exports. Eriksen computed the theoretical ton-mile demand that would arise if the historical pattern of seaborne trade in each year had been such as to minimize total transportation costs subject to the constraint that total exports from, and import requiremets into, each area being equal to their historical values. He then computes an index of efficiency of transportation defined as the ratio of the computed theoretical "cost transportation minimizing ton-miles" to actual ton-miles. This is done for various years. He then finds that the efficiency of transportation moves in line with the level of freight rates. This reflects the fact that when freight rates are high more trade is undertaken in the short haul routes rather than in the long haul routes in order to economise on freight costs. These results suggest that the demand for freight services varies inversely with freight rates.

Norbulk

Another study of the aggregate demand for freight is that of Wergeland (1981). The author estimated an aggregate model of the world dry bulk freight market (NORBULK). The model consists of a a supply function of freight which is identical to (1) as well as a demand for ton-miles function which, following the results of Eriksen (1977), is hypothesized to be positively related to the level of world trade T and negatively to freight rates as in (10).

$$q = T^{\delta}F^{-\varepsilon} \tag{10}$$

Both δ and ε are expected to be positive with δ being possibly equal to one. Data for the period 1965 - 1974 have been used for estimating the unknown parameters. Equations (1), (10) are estimated by 2SLS and FIML in log-linear form giving the following results under FIML

$$\underset{(0.036)}{q = 1.379T} - \underset{(0.02)}{0.077F} \tag{11}$$

$$q^{S} = \underset{(0.034)}{0.486K} + \underset{(0.062)}{0.266F} - \underset{(0.060)}{0.120P_{b}} \tag{12}$$

and these are very similar to the results derived by two stage least squares. The figures in the parantheses are the standard errors of the estimated coefficients. It can be seen that most of these are well determined with the sign and magnitude of the coefficients conforming to a priori expectations and the results derived by other empirical studies. The demand for freight is estimated to be very inelastic with respect to freight rates. The price elasticity of demand is calculated to be *-0.077*. Supply of freight services is also calculated to be fairly inelastic with respect to freight and fuel prices. These calculated coefficients do not seem to differ significantly from those estimated by Tinbergen or Koopmans and others. The only unusual result is the coefficient on the fleet size in the supply function which is significantly lower than its theoretical value of 1.

In order to simulate the model, Wergeland constrains the coefficient on the fleet to equal its theoretical value of 1 while the elasticity of demand with respect to freight rates is set equal to -0.4 and after some other minor changes to the other estimated coefficients the model is used in order to carry out ex post forecasts of freight rates over the period 1974 - 1978. For these purposes the form of the supply function is appropriately adjusted to take account of the option of lay-up. When rates are above the level at which ships will enter into lay-up supply is given by (1) while at the lay-up rate supply becomes completely horizontal and is no longer determined by (1). The simulations results track the actual developments with a high degree of accuracy.

The low coefficient on the fleet size is very puzzling since the a priori belief that the elasticity of supply with respect to the fleet is 1 is very strong. Most studies including our own, do indeed constrain this elasticity to be equal to 1 so these disturbing results might cast some doubt on whether this is appropriate. It might suggest for example that there is some important omitted variable affecting the supply and which is correlated with the variables usually included in the regressions causing a bias in the results. We have reproduced the results of Wergeland and it turns out that the demand data is not compatible with that used for the fleet. The data for demand used in the study refers to total shipments of goods in dry bulk form while the data for the fleet refers to the bulk carrier fleet. However the demand data includes shipments in bulk which have not been transported by bulk carriers but by other dry cargo tramp ships. The supply equation is meant to represent the freight services offered by the bulk carrier fleet. This is not equal to the demand index used since the latter includes a significant amount of bulk goods transported by other dry cargo tramp ships. The market share of the other dry cargo ships in total bulk shipments, was falling very rapidly over the estimation period. This is a period of considerable structural change as the bulk carrier fleet expanded rapidly from a very low market share in mid sixties, and eventually dominated the market by the mid seventies. The rapid growth of the bulk carrier fleet is not reflected in the data for bulk shipments used since other dry cargo ships were rapidly leaving this market over the period. This results in a downward bias on the coefficient of the fleet. The results therefore do not cast doubt on the a priori expectation regarding the effect of the fleet on supply nor does it suggest the presence of omitted variables in the supply function.

Nortank

Norman and Wergeland (1981) developed a theoretical model of the freight market for large tankers (NORTANK). Large in this case refers to tankers over 200,000 DWT. The model is quite disaggregated distinguishing between 4 different large types of tankers. Unlike most other models of the shipping markets NORTANK is not estimated econometricaly but uses micro data on the technology of the four ship types in order to derive the theoretical supply of ton-miles generated by each ship type. Then the total supply in the market for large tankers can be found by simply adding up the supply generated by the individual types.

The theoretical determination of optimum speed is considered in a context which takes account of various real world features which are usually ignored in aggregated models. A representative round trip is considered which involves carrying oil over a particular distance. A production function which relates ton-miles (which is an index of fixed distance voyages performed) and fuel consumption to the speed of ships is implicitly specified. The specification takes into account the waiting time in port, the capacity utilization of ships' space and other complications. Revenues are proportional to voyages performed which in turn mirror the speed of the fleet. Fuel (variable) costs depend on speed. The technological relationship between speed and fuel consumption is derived from micro data. Profits are then maximized with respect to speed and this implies that the optimum speed is a function of freight rates, fuel prices and other operating costs. Thus the mathematical relationship between speed and prices embedded in the freight market model is derived theoretically from a priori knowledge of the production function rather than econometrically from aggregate ton-mile and price data.

This relationship is derived separately for each ship type and then the total market supply is defined as the sum of the individual ship type supplies. The profit maximization problem can lead to corner solutions. This is because the speed of the ship is physically constrained to lie between a minimum value of around 9 miles per hour and a maximum of around 15 miles per hour. This is then reflected in the shape of the individual ship type supply functions. There is a minimum rate below which all ships belonging to a particular type will move into lay-up and thus supply will be equal to zero. At that minimum rate the shipowner is indifferent between lay-up and operating the ship. Thus supply is perfectly elastic at that point. A small increase in rates will lead to all ships breaking lay-up which is now the more costly option. There is a range above the lay-up rate where ships will run at the minimum speed and thus supply is completely inelastic in that region. Above this range, supply becomes elastic as increases in rates cause the ships to run faster. This is until rates increase to a level which induces the ship to run at full speed. Thus above this rate supply again becomes completely inelastic as speed cannot be further increased. Thus there are three kinks in the supply curve generated by an individual ship type.

The demand for freight services of large tankers is assumed to be completely inelastic with respect to rates. This reflects both the fact that demand for oil is inelastic at least in the short run and also the fact that in recent times freight costs have constituted a small percentage in the final price of oil. The equilibrium freight rate for large tankers can be determined by setting the total market supply equal to the exogenously specified level of demand for large tankers' freight services.

Price determination in the time charter and second hand markets - Strandenes, (1984)

Strandenes (1984) reports the results of an investigation into the determinants of time charter rates and second hand prices. A time charter hire contract stipulates that for a given period of time τ, control of the ship is passed over from the shipowner to the charterer. In return, the charterer must pay a rent which is a negotiated fixed amount of money per period known as the *time charter rate* H^{τ}. The time charter rate will normally vary with the duration of the contract τ. The contract also stipulates that fixed operating costs such as wages are paid by owners while the variable costs (fuel and port charges, canal dues etc.) are paid by the charterer. According to the efficient markets theory the present value of a time charter contract should be equal to the expected present value of the spot market profits (before fixed operating costs) over the duration of the contract, after allowing for risk. In shipping terminology, the flow concept of profits before operating costs $\tilde{\pi}$ is, for obvious reasons, called the *time charter equivalent* (TCE)[2].

We can distinguish between various time charter contracts and associated time charter rates depending on the duration of the contract. For short term time charter contracts it is mainly the short term TCE earned on the spot market that should theoretically determine the associated time charter rate. For long term time charters however the expected longer term TCE of the spot market should be more relevant for determining the corresponding time charter rate.

One of the objectives of the study is to determine the actual importance of short term and longer term

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[2] In other words the accounting relationship between profits π, time charter equivalent $\tilde{\pi}$, and operating costs OC is the following:

$$\pi = \tilde{\pi} - OC$$

expected TCE on the level of various (short or long term) time charter rates. To do this the following relationship is specified

$$H_t^{\tau} = \rho(\tau)[a_{\tau}\tilde{\pi}_t + b_{\tau}\tilde{\pi}_t^{L}] \tag{13}$$

where

H_t^{τ} = time charter rate on a τ year contract arranged at time t

$\tilde{\pi}_t$ = current (short term) time charter equivalent

$\tilde{\pi}_t^{L}$ = expected long term time charter equivalent

and where $\rho(\tau)$ is meant to represent a risk premium factor that might vary with the duration of the contract. If $\rho(\tau) = 1$ and $a_t + b_t = 1$ then there is risk neutrality while if $\rho(\tau) < 1$ this would imply that owners are prepared to accept lower profits on a safe time charter than from the expected profits to be earned on the more risky spot operations. Since the riskiness of the alternative spot strategy increases with the length of time τ, it might be expected that $\rho(\tau)$ is also a decreasing function of τ. The author constructs measurements of the short term and long term expected TCE of the spot market and uses these to estimate the parameters of (13) by OLS. The model is estimated separately for bulk carriers, medium size tankers and large tankers. Data covers the period from the late 1960s up to early 1980s. The results for medium size tankers reported by the author are reprinted on table 2.1. These are representative of the results derived for the other sectors as well. In row 1 the effect of the short term TCE on charters of various duration is shown. It can be seen that a $1 increase in short term TCE leads to a 60 cents increase in the short term time charter while the long term charter rate increases by only 26 cents. Row 2 shows the effect on the time charter rate of an increase

Table 2.1

Medium Size Tankers

Sensitivity of time charter rates to changes in short term and long term expected TCE

	Charter Duration (τ)		
	0 - 12 months	**13 - 36 months**	**over 36 months**
Estimated effect on $\tilde{F}^{\tau}$ of:			
$1 increase in short term TCE	60¢	47¢	26¢
$1 increase in long term TCE	44¢	51¢	70¢
$1 increase in both the short and long term TCE	104¢	98¢	96¢

Source: Strandenes S.P. (1984), page 24 in the long term TCE. It indicates that a $1 increase in the long term TCE leads to a 70 cents increase in the long term time charter while the short term time charter increases by only 44 cents. By comparing the figures in row 1 and row 2 for different charter lengths it can be seen that short term time charters are more sensitive to expected short term TCE than to the long run TCE while the opposite is true for long term ones, as we expected.

Row 3 is the sum of the two other rows and it therefore represents the total effect on the time charter rates of a permanent increase in both the short term and long term TCE. If there is risk neutrality the theoretical entries in this row should be equal to $1. Because of the small size of the sample the estimated effect is subject to some margin of random error but perusal of the similar results reported by the author for the other sectors in addition to the ones reprinted here indicates that the risk premium is probably small while its magnitude increases with the length of the charter. The small size of the risk premium is indicated in Table 2.1 by the fact that the entries in row 3 are close to 1. The conclusion that the size of the risk premium increases with the length of the charter rests on the fact that the size of the entries in row 3 decrease as the duration of the contract increases. This is true not only for the medium size tanker sector figures, reported in table 2.1 but also for the other tables reported by the author concerning the other sectors.

In the same article Strandenes investigates the sensitivity of ship prices to short term and long term expected profitability. The following relationship between ship prices P_t, short term profits π_t^s and long term profits π_t^L are specified:

$$P_t = k((a/(r+d))\pi_t^s + (b/(r+d))\pi_t^L) \tag{14}$$

and where d is the depreciation factor, r is the return on capital while k is a nuisance accounting constant whose value is known a priori. We might expect that the sum of the coefficients *a*, *b* should equal 1. Equation (14) can be written as

$$P_t = k(u\pi_t^s + v\pi_t^L) \qquad (15)$$

where

$$u = a/(r+d)$$

$$v = b/(r+d)$$

Because the economic lifetime of ships is very long we expect that the effect of short term profits on prices to be small while the effect of long term profitability should be much larger. In terms of equation (15) this implies that *u* should be small relative to *v*. The coefficients *u*, *v* of (15) are estimated econometrically using data for the period covering the late 1960s up to the early 1980s. Separate estimates are reported for the bulk carrier, medium size and large tanker sectors. These results are reprinted in Table 2.2. It can be seen from the table that the estimated coefficient on long term profits is in general much higher than the coefficient on short term profitability. This indicates that the effect of long term profitability on prices is much higher than the effect of short term profits. Only the prices of large tankers seem to be more sensitive to short term profitability than to the level of long term profits. The hypothesis that the response of prices to profits is dynamic was tested by introducing lagged values of the variables in the regression. For the bulk carrier and medium size tanker sector the static equation (15) could not be improved upon by an extended dynamic version. In the case of large tankers however it was found that the inclusion of lagged short term profits led to a significant improvement in fit. The t - statistics reported in the last row of the table are relevant for testing the hypothesis that $a + b = 1$. The tests support

Table 2.2[3]

Sensitivity of ship prices to short term and long term profits

	Dependent variable: Second hand prices of		
	Panamax Bulk Carriers	Medium Size Tankers	Large Tankers
Estimated effect of:			
π^s_t	22.99	17.14	34.31
	(4.67)	(5.51)	(3.56)
π^s_{t-1}			25.25
			(3.54)
π^L_t	77.27	57.48	30.26
	(6.20)	(15.83)	(5.84)
Test of restricting (a + b = 1) t - value	1.98	-1.06	-0.52

Source: Strandenes S.P. (1984), page 40

[3] Standard errors in parentheses.

the hypothesis on the sum of the coefficients *a*, *b* in the case of the medium size and large tankers. In the case of the bulk carrier market, however, the hypothesis was marginally rejected.

Norship

The freight market models Norbulk, Nortank and the results of Strandenes (1984) together with other research on the shipbuilding and scrapping markets have been integrated by the authors into a model of the bulk shipping markets. The structure of this integrated model (Norship) is explained in Strandenes (1986). The model consists of a freight, second hand, shipbuilding and scrapping market. It distinguishes between two main sectors which are the tanker and bulk carrier sector. The tanker and bulk carrier fleet are further divided into large and small vessels.

Supply in the freight market is modelled along similar lines as in Norbulk and Nortank. Here, the behaviour of combined carriers[4] is taken into account. The combi fleet is assumed to move from the tanker freight market to the dry bulk freight market so as to maximize profits from trading. Thus the proportion of combis in the one market is likely to depend on the relative profitability of the two markets. In addition the bulk carrier and tanker fleet have been disaggregated into small and large vessels. Thus a separate supply of ton-miles function has been specified for each vessel type. Total supply in the bulk carrier market is then the sum of the supplies generated by the small, the larger bulk carriers and the combis in dry. This must equal the demand for dry bulk transportation services. Similarly, supply in the tanker market is the sum of the supplies

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[4] These are versatile dual purpose vessels that can switch from the tanker freight market to the dry bulk market and vice versa.

generated by the small, large ships and the combis in oil. This must also equal the total demand for tanker transportation services.

For each type of vessel the time charter rate for a contract of duration of τ years is assumed to be a weighted average of the short term and long term time charter equivalent. As in Strandenes (1984) the weights depend on the duration of the charter with relatively more weight given to short term expectations when τ is small while the opposite is true for longer term charters. To determine the long term profitability π^L and the associated time charter equivalent $\tilde{\pi}^L$ the following argument is used. At equilibrium and in perfectly competitive markets the return on a newbuilding must equal the return on capital r. This implies the following relationship between long term TCE ($\tilde{\pi}^L$), long term operating costs OC and newbuilding prices P_n

$$P_n = \frac{1}{r + d} (\tilde{\pi}^L - OC) \quad (16)$$

and this allows $\tilde{\pi}^L$ to be determined in terms of P_n, r, d and OC.

Second hand prices are determined in a similar way as in Strandenes (1984). Thus second hand values are assumed to be a weighted average of short term profits π^s and long term profits π^L as in (15). The accounting identity that defines the time charter equivalent determines the relationship between $\tilde{\pi}^L$ and π^L (see footnote 2).

In the scrapping market the supply of ships for scrap S_i generated by the i^{th} ship type is assumed to be a function of the ratio of ship values to scrap prices P_s as follows

$$S_i = k_1 (P_s/P_i)^{k_2} \quad (17)$$

In the shipbuilding market demand and supply functions for new ships of each type are specified. Demand for new ships is assumed to be negatively related to the price of newbuildings Pn and positively related to the discounted stream of profits V anticipated over the lifetime[5] of the ship using the profitability of a perpetual time charter as the relevant expected net income of the ship

$$V = k \frac{1}{r + d} (H^{\infty} - OC) \tag{18}$$

where k is a time dependent constant that controls for the effect of the time of delivery lag on the value of the newbuilding contract. Demand for new ships of type i DN_i is then assumed to be given by the following relationship

$$DN_i = k_i \, (V_i/Pn_i)^{k'_i} \tag{19}$$

where k'_i is the elasticity of demand of new vessels.

The marginal cost of building an extra ship is assumed to be positively related to the amount of total construction of all types of ships relative to the available maximum capacity. At equilibrium the marginal cost (net of subsidy) equals the newbuilding price. The time of delivery lag, which affects the value of the newbuilding contract is positively related to the amount of ships on order relative to the available capacity. The newbuilding market clears by means of changes in the level of newbuilding prices. Shipbuilding capacity is treated as exogenous.

In table 3 of Strandenes (1986) the author reports the simulated path of the endogenous variables under a reference base run set of exogenous assumptions. Then the level of bunker prices is reduced by 36% from year 2 of the simulation onwards and a new forecast is generated under this new set of assumptions. These results are

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[5] This can be assumed to be around 15 years or so.

reported in Table 4 of Strandenes (1986). Our Table 2.3 reports the percentage differences in the time path of selected endogenous variables that arise as a result of such a bunker price shock. It has been constructed by taking percentage differenes of the simulated time paths of the system, before and after the shock, as reported by Strandenes (1986) int the relevant tables.

As can be seen from Table 2.3 a drop in the bunker price leads to significant drops in the level of tanker and dry bulk freight rates. This drop in freight rates is permanent. Because tankers spend relatively less time in port and more time steaming than dry bulk carriers, the percentage of fuel costs out of the total is higher. This also makes the supply of tanker freight services more sensitive to the price of bunkers than the supply of dry bulk transportation services. As a result supply of tanker ton-miles expands more than the supply of dry bulk ton-miles so that there is a tendency for tanker rates to fall much more than dry bulk rates. This tendency is however partly cancelled by the fact that combined carriers will tend to switch from oil to dry should such a gap in relative rates occur. It can be seen from the table that combined carriers do indeed switch to the dry market following the drop in the bunker price. This makes the drop in the tanker freight smaller than would otherwise have been and that of the dry bulk carriers higher.

The effect of the drop in the price of bunkers on profitability depends on the elasticity of demand. It can be seen that on the one hand costs decrease as a result of the drop in the bunker price but on the other hand freight rates also decrease and this has a negative effect on profitability which can completely outweigh the positive direct effect of the drop in the fuel costs. Whether the positive direct effects of the drop in costs outweigh the negative indirect effects of the drop in rates crucially depends on the elasticity of demand. If demand is perfectly elastic with respect to freight rates the equilibrium freight rate remains unchanged following

Table 2.3

Simulated effects of a
36% Decrease in Bunker Prices
(Percentage Changes)[6]

Year	Tanker Freight Rates	Dry Bulk Freight Rates	Tanker Fleet	Dry Bulk Fleet	Combined Carriers in Oil
1	0.0	0.0	0.00	0.00	0
2	-20.9	-19.2	0.00	0.00	-13
3	-20.3	-15.7	-0.19	-0.05	0
4	-19.3	-16.7	-0.16	0.00	-5
5	-22.5	-17.1	-0.42	0.25	-25
6	-22.6	-14.6	-0.74	-0.29	-22
7	-21.3	-14.3	-1.08	-0.37	-19

	Large Tankers		Small Dry Bulk Carriers	
Year	Time Charter Equivalent	Second Hand Price	Time Charter Equivalent	Second Hand Price
1	0.0	0.0	0.0	0.0
2	0.0	-4.5	-11.9	-6.4
3	0.0	1.7	-5.2	-0.8
4	-5.3	-6.3	-7.8	-5.2
5	-15.8	-9.7	-9.2	-3.8
6	-16.3	-10.4	-6.8	-3.2
7	-12.6	-9.1	-7.2	-4.5

Source: Strandenes S.P. (1986), calculated from Tables 3,4 in pages 31,33

[6] Combined carriers in oil: changes in percentage rate

the drop in the fuel price and the consequent shift in supply. This then implies that shipowners collect all the benefits (costs) of a decrease (increase) in fuel prices. When, however, demand is very inelastic, as is the case here, the change in the fuel price leads to significant changes in the equilibrium freight rates as the supply shifts. In this case shippers bear all the costs (benefits) of an increase (decrease) in the price of bunkers. Freight rates drop significantly following the drop in the fuel price and this leads to a decrease in the profitability of spot market operations. This is shown in Table 2.3 by the fact that the time charter equivalent drops.

The drop in profitability tends to be corrected in the longer term as lower profits imply lower prices which cause the fleet to respond. The drop in the second hand value of ships leads to an increase in the supply of ships for scrap and the drop in profitability leads to a decrease in the demand for new ships. This causes the fleet to contract in the long run and this helps to improve the profitability of the spot market.

2.4 Hawdon's integrated model of the tanker market

Hawdon (1978) develops a model that determines tanker freight rates in the short run and in the long run. In the short run the fleet is fixed and freight rates can be determined by simply considering the freight market. In the long run however the fleet changes with market conditions and thus the markets for ships must be considered explicitly. Hawdon's model consists therefore of a freight market, a shipbuilding market and a scrap market. The model is estimated using data for the period 1950 - 1973. A reduced form equation for freight rates which in spirit is similar to equation (3) is specified. This is estimated by regressing tanker rates on the right hand side variables of (3) i.e demand per unit of capacity, fuel prices and in addition some other exogenous and endogenous variables have been included. This list of other variables includes the level of dry cargo freight rates the price of new tankers, wages of seamen, the average size of ships and various dummies. There is no theoretical suggestion that the price of tankers can influence the supply of freight services in the short run given the fleet, and thus not surprisingly Hawdon finds that this variable is not statistically significant for explaining the fluctuations in tankers rates.

Labour is an input in the production of transportation services and thus we theoretically expect that they should have a negative impact on the supply of freight services and a positive effect on rates. The inclusion of the average size as an additional explanatory variable possibly reflects the idea that large tankers are considered to be more efficient than small ones.

Perhaps suprisingly Hawdon finds that the wages of seamen and the average size of tankers is also not statistically significant for explaining rates. The idea behind the inclusion of the dry cargo freight rate as an explanatory variable in the reduced form for tanker rates is that over the estimation period a part of the tanker fleet was engaged in the dry cargo routes. These have been the tankers in grain and the combined carriers in dry. When the dry cargo freight rates increase we expect that a higher number of tankers is likely to be employed in the dry cargo trades leading to a reduction of supply in the tanker freight market and an increase in rates. In practise the possibility of tankers switching between oil and grain is very limited while the combined carrier fleet, which is more versatile, constitutes only a small proportion of the total supply, especially over the estimation period. Thus not surprisingly Hawdon finds no statistically significant evidence of a dry cargo freight rate influence on tanker rates. Similarly he also finds no evidence of a tanker freight rate influence on dry cargo rates. However as in other studies the influence of demand relative to the fleet and of fuel prices on rates turns out to be statistically significant. These results should be treated with caution because again here an incorrect index of transportation demand has been used. Demand has actually been measured in tons of oil transported by sea instead of in ton-miles. The former does not take into account changes in the average distance which over the estimation period had been increasing.

Hawdon's reduced form equation relates equilibrium short run tanker freight rates to the prevailing level of demand, fleet and fuel prices. At a point in time the size of the fleet is given. In order to explain the dynamic evolution of rates over a longer term period Hawdon explicitly considers shipbuilding and scrapping of tankers. In the shipbuilding markets "shipowners are assumed to order new capacity if the volume of oil trade increases, if the freight rate increases, or if the price of new ships falls". Thus Hawdon estimates a demand for new tankers by regressing orders on prices of new ships, freight rates and the volume of oil trade. The results indicate that demand for orders increases with the volume of trade. However the estimated coefficient of prices turns out to be positive which is contrary to what was expected while the coefficient on freight rates is statistically insignificant. These results strongly suggest that Hawdon has actually estimated a supply schedule rather than demand. The estimated coefficient on prices reflects the positive effect of new ship values on supply. At the same time the trending oil trade variable acts as a proxy for the also trending shipbuilding capacity variable which would appear in a newbuilding supply function. This strong correlation between the two variables causes the oil trade variable to pick up the positive effect of capacity on supply. This view also explains the insignificance of the freight variable since this is not theoretically expected to appear in the newbuilding supply function.

To complete the shipbuilding market Hawdon does not specify an explicit supply function for new tankers but substitutes the supply function into the demand for orders and solves for the reduced-form newbuilding price which is expressed as a function of those variables that can shift either the demand for orders or the supply. The supply is hypothesized to depend negatively on the price of steel which is an input to the shipbuilding process. Thus newbuilding prices are regressed on freight rates and the price of steel among other variables. Freight rates and steel prices turn out to have a positive effect on prices as was expected. This part of the model determines equilibrium newbuilding prices and orders. Deliveries are then hypothesised to depend on lagged orders. Deliveries are therefore regressed on orders and the results indicate that orders have a positive effect on future deliveries.

The important factor for determining scrapping is assumed to be the expected future stream of profits of old ships. The latter is implicitly assumed to be projected on the basis of recent levels and trends in freight rates and the level of demand. The supply of ships for scrap is also likely to be proportional to the size of the fleet. Thus scrapping is regressed on freight rates, the level of demand and the size of the fleet. All estimated coefficients turn out to have the correct sign. Thus according to the empirical estimates freight rates and demand have a negative impact on scrapping while the fleet has a positive effect on the supply of ships for scrap. Finally in order to close the model the change in the size of the fleet is given by the difference between deliveries and scrapping.

The estimated model is then simulated and its response to various shocks is considered. This is done by solving the model for a given set of exogenous assumptions. Then an exogenous variable is changed by a fixed percentage amount and the new solution is computed. The two solutions are then compared. The main simulation results are shown on Table 2.4. The model simulations

Table 2.4

Impact and long run elasticities of endogenous variables

	Trade Shock			Bunker price Shock		
Year	0	6	∞	0	6	∞
Endogenous Variable						
Freight rate	3.1	0.6	-0.6	1.7	1.9	1.9
Orders	2.0	1.7	1.7	0.2	0.0	0.0
Deliveries	0.0	1.3	1.4	0.0	0.0	0.0
Scrapping	-1.2	0.3	1.4	0.0	0.0	0.1
Fleet	0.1	0.7	1.2	0.0	0.1	0.1

Source: Hawdon D. (1978), page 215

imply that a 10% permanent increase in trade leads to a 31% increase in freight rates in the first year. This also increases the demand for orders and reduces scrapping thus the fleet expands in the following years bringing rates down. Thus after six years the increase in freight rates is only 6% and in the long run it becomes negative. The fleet rises by 1% initially, 7% by year 6 and in the long run by 12%. The effects of an increase in fuel prices are also considered. A 10% permanent increase in the price of fuel leads to a 17% increase in freight rates initially and a 19% increase in the long run. The fleet is constant initially but rises in the long run by 1% suggesting that an increase in bunker prices leads to permanent slow steaming.

2.5 Charemza and Gronicki Disequilibrium model

Charemza and Gronicki (1981) also consider an integrated model of the shipping markets which consists of a freight market a shipbuilding market and a scrap market. The model is applied to both the dry cargo and the tanker markets. The distinguishing feature of the model is that it allows for the possibility of disequilibrium in the freight market and the markets for ships. Thus demand in a market does not necessarily equal supply in every time period and prices are not perfectly responsive to changes in either supply or demand. Since in such models prices do not move to clear the markets, the equilibrium price cannot be determined by assuming equality of supply and demand. Therefore a different rule must be specified that describes the sluggish adjustment of prices to excess demand or supply. The usual assumption of disequilibrium models, which the authors also make, is that the change in price is directly proportional to the level of excess demand. The other assumption that is made in disequilibrium models is that the actual quantity exchanged in the market is not equal to supply and demand but to the minimum of the two. Agents on the long side of the market are rationed.

The model consists of a freight market section and a shipbuilding and scrapping block. The determination of time charter rates on long term contracts is also considered. In the freight market demand is determined exogenously by world trade and is completely insensitive to freight rates. Supply of freight services depends on the size of the fleet and freight rates. Supply in the current period is not necessarily equal to demand since the response of rates to excess demand is sluggish. The actual change in the freight rate is assumed to be proportional to this level of excess demand. The long term time charter is hypothesized to respond with lags to the level of spot rates and to the level of demand in relation to the fleet.

The freight market model is estimated using data for the period from 1961 up to the early 1980s. The estimation procedures must take account of the fact that the actual quantities exchanged and observed are not in general equal to supply and demand but to the minimum of the two. In some disequilibrium models, and also in this one, the price adjustment rule enables the econometrician to infer what the excess demand is and allows him to estimate the unknown parameters of the demand and supply equation. Because the model is formulated in linear rather than log-linear the estimated coefficients cannot be interpreted as elasticities. The t-statistics reported however do indicate that the freight market supply in the tanker and dry cargo market is indeed influenced by changes in the size of the fleet and freight rates. The long term time charter is, according to the results, positively affected by freight rates and the level of demand in relation to the fleet.

The theoretical structure of the shipbuilding and scrapping blocks is not explicitly presented in the text so discussion of this part of the model must rest on the reported estimated equations., This prevents us from comparing the actual results with an explicitly specified theoretical structure. In the shipbuilding block the demand for tonnage is estimated to depend negatively on the level of prices and positively on the level of demand for freight. This is a demand for existing tonnage and not for new ships and thus it might be interpreted as an asset demand for ships although the authors do not suggest such an interpretation. A separate demand for new orders is also estimated to be positively related to the level of demand and the long term time charter and negatively related to the size of the fleet. On the supply side of the newbuilding market the model distinguishes between new orders for ships, ships commenced, launches and deliveries. Ships commenced represent the amount of newbuilding tonnage on which construction was initiated during the period. Launches can differ from deliveries because in many cases a ship is launched as soon as the main body is ready and while there is still work to be done on it before it is delivered. Supply of new orders is assumed to depend positively on the price of ships and to a proxy of shipbuilding capacity. The market for new orders is not assumed a priori to clear instantaneously and the price of ships is assumed to respond sluggishly to the excess demand or supply in that market. By partly solving the model it can be seen that deliveries eventually are indirectly determined by a distributed lag formulation on past orders. The detailed specification of the model assumes that deliveries are a function of current and lagged launches. These in turn are a function of current and lagged commencements of new ships. The latter are finally specified to be determined by current and lagged new orders.

The scrapping of tonnage is estimated to be positively related to the size of the fleet and negatively to the level of the long term time charter. Finally the change of the fleet is simply the difference between deliveries and scrappings.

2.6 Dynamo, an integrated model of the tanker market

Rander (1984) summarizes the main structure of a version of the Dynamo tanker model. This model consists of a tanker freight market, a shipbuilding and scrapping market. One of the distinguishing features of the freight market sector of the model is that the fleet is disaggregated into tankers that operate in the spot market and tankers that operate under a time charter contract. The specified supply of ton-miles generated by a unit of capacity differs depending on whether the vessel under consideration is time charter free or not. According to the model the response of spot vessel supply to freight market conditions is immediate while, according to the authors, time chartered vessels are locked into contracts which possibly do not replicate the incentives for profit maximization and the consequent spot market behaviour that this generates. When the ship is on time charter there is no incentive for the owner to maximize profits by trading the ship efficiently since this does not affect his earnings which are determined by the the prearranged time charter rate and fixed operating costs. Thus the response of the supply generated by the time chartered fleet might be more sluggish than the response of the spot vessels.

In contrast to this approach adopted by Dynamo, most other models do not distinguish between time charter free and spot vessels. This is because the time charter market resembles a futures market which, as is well known, tends to be peripheral to the spot market. A time charter contract will reduce both the spot demand and spot supply by exactly the same amount leaving the equilibrium spot rate unaffected. Thus, although the futures markets are affected by expected developments in the spot markets they do not in turn affect the spot market itself. This is indeed the prevalent view among participants in the freight market. Because the charterer pays for the voyage (variable) costs and controls the utilization (fuel consumption and time in port) of the vessel, the incentive of efficient trading is infact maintained.

According to these arguments the vessels' utilization will be the same whether the ship is on the spot market or whether it is time chartered by either a shipper or a speculator. The fact that operating costs such as wages have to be paid by the owner even when the vessel is under time charter, does not affect the outcome of the decision. Although there would no longer be an incentive to employ the optimal amount of labour and those other factors that are associated with operating costs this does not make any difference simply because these are fixed factors. It is thus seen that a time charter is a fully efficient contract in many ways. On the one hand it stipulates that operating fixed costs and factors are for owners' account. Because these are fixed, the decision of profit maximization with respect to fixed factors is simply that of finding the cheapest available on the market. For this the owner is likely to have an advantage since this is part of his ordinary business and he thus probably has a better knowledge of the various alternatives available and lower contracting costs. On the other hand because variable costs are for charterers' account, the incentive of profit maximization in a free spot market - which usually contributes to efficient allocation of resources - is fully replicated.

There is another argument which is used to suggest that spot and time chartered vessels might generate a different quantity of supply at a given point in time. This is that tankers are mainly time chartered by big oil companies so the hired vessels then become part of their efficient integrated system of transportation. Thus tankers on time charter might spend less time in port waiting for a cargo to load than spot vessels and might perform shorter ballast trips. Even if this is true it does not however imply that the response of the time chartered fleet to market conditions is not immediate.

In the freight market block as well as in other parts of the model, behaviour of economic agents is assumed to be influenced by the projected freight rate rather than the current spot rate. This represents the expectation of a future freight rate. A whole range of projected freight rates is defined by changing the projection horizon. In some relationships it is the short term projected rate that enters and in some others a longer term one. This expected freight rate is roughly speaking modelled as a projection of long term trends through the latest 12 month average rate. The long term trend is estimated by fitting a line through two points. The first point is the latest annual average and the second point is another average over a longer term historical period.

The freight market is assumed to clear instantaneously so freight rates are determined by the condition that demand must equal supply. A large part of the freight market model is concerned with analyzing the determinants of the short term and longer term fluctuations in demand for tanker freight. Since we are here only interested on the impact of a given time path of demand on the shipping markets and not on the prior causes of such shifts in transportation requirements, we here only concentrate on commenting on the modelling of supply. This does not imply that the analysis of demand shifts, like the one embodied in Dynamo, is not interesting in itself. In passing we note that Dynamo like other models treats demand as completely inelastic with respect to freight rates.

In the freight market supply is identically equal to the size of the tanker fleet minus the laid up ships times the vessel utilization rate as in equation (20). The utilization rate is the number of transportation services generated by a *trading* ship. It is actually defined by equation (20).

$$q^s = K(1-\lambda)u \tag{20}$$

where

λ = fraction of ships laid up

u = utilization rate

Both λ and u are positively related to freight rates. The utilization rate i.e the number of transportation services produced per trading ship can change by either increasing the speed of the ship or by reducing the time in port or the number of days under repairs. The fraction of ships in lay up should be obviously related to the profitability of the spot market relative to the costs in lay up. When rates increase and profitability is high, only a very small proportion of ships is expected to be laid up. On the other hand when rates are low and profitability of the spot market becomes negative, then losses might be minimized by laying up. More ships are then expected to be laid up. Since however there are costs of moving in and out of lay up the relationship between lay up and freight rates should be dynamic with expected freight rates also influencing the current decision. Thus current lay up is specified to depend on the projected freight rate and lagged lay up.

The utilization rate u is identically equal to a weighted average of the spot and time chartered fleet utilization rates with the weights being proportional to the percentage of ships operating in the spot market and under time charter contracts. As in other freight market models the utilization of spot vessels is assumed to depend on current freight rates relative to voyage costs. The response of the time chartered fleet utilization rate to market conditions is assumed to be more sluggish. The change in the utilization rate of the time chartered fleet is assumed to depend on the projected freight rate.

The model also consists of a shipbuilding and scrapping block. For the purposes of determining scrapping the fleet is disaggregated into new (less than 10 years old) and old (over 10 years old) ships. No ships under 10 years old are assumed to be scrapped and this allows the evolution of this age profile of the fleet to be determined from knowledge of the history of deliveries and scrappings. The annual change in the size of the old fleet is equal to the amount of deliveries of new ships 10 years ago minus the current scrappings. The proportion of the old fleet scrapped is assumed to be a function of the projected freight rate.

The shipbuilding block is more complicated. Deliveries of new tankers are assumed to depend on the amount of tanker construction initiation T years ago, where T is the time it takes to construct a tanker. Construction initiation is assumed to be proportional to the tanker construction capacity and the fraction of tanker capacity in use. The latter is a function of the order backlog relative to the tanker construction capacity where here by order backlog we shall mean the amount of tankers on order but as yet not under construction. The change in the order backlog is identically equal to the amount of contracting of new vessels minus cancellations minus construction initiation. Cancellations are a function of the projected freight rate and the future tonnage needed relative to the tonnage on the order backlog. Contracting of new vessels is assumed to depend positively on the amount of new tonnage needed and to the projected freight rate and perceived scrapping. Perceived scrapping is determined by a lag distribution on actual scrapping. New tonnage needed is positively related to the projected level of demand relative to the perceived supply at normal designed utilization[7]. It is also negatively related to the order backlog. The projected level of demand is

[7]The author specifies the new tonnage needed function in terms of the projected loading capacity relative to the perceived loading capacity. The former is proportional to the level of demand with the factor of proportionality being the average length of the voyage while the latter is proportional to the supply with the constant of proportionality being the normal utilization at the designed speed and time in port.

determined in exactly the same way as the projected freight rate. The perceived supply at normal utilization is determined by a lagged distribution on actual normal supply.

2.7 Martinet, a disaggregated model of the tanker freight market

Martinet is to our knowledge the most disaggregated model of the tanker freight market. It is indeed not a model of just the tanker freight market but of the international oil transportation network. It distinguishes between 10 tanker sizes which are further disaggregated by flag of registration and for each type of tanker it determines the equilibrium freight rate.

Since the markets for ships are not modelled, Martinet can only be used for short term forecasting with the size of the fleet of various tanker types being input exogenously. The set of exogenous variables of the model in addition includes the level of consumption of 26 importing regions and the level of production of 31 producing regions. It also incorporates a detailed description of the world oil transportation network. Thus the length of 460 tanker routes is specified as well as the existing pipeline capacities, transhipment facilities, canal and terminal restrictions as well as canal and terminal tolls.

The model determines the equilibrium fob and cif crude oil prices and the equilibrium freight rates for tankers of various sizes. The equilibrium oil flows among the various regions as well as the types and amount of tankers employed in each route are also calculated. It does this by assuming that in equilibrium there should be no possibility for an oil trader to make an arbitrage profit by simply buying oil from one region and selling to another. It also assumes that at equilibrium the employment pattern of the tanker fleet should be such that no ship could increase its profits by trading on another route.

The optimal speed and employment pattern of ships is determined subject to various constraints. Thus large tankers are excluded from trading in those routes where the draft restrictions prevent these ships from entering either the loading or discharging port. They are also excluded from passing through canals if the draft restriction does not allow it. However it might be possible for a tanker to go through the canal unloaded but not loaded. These possibilities are also considered. Thus large tankers can make a return trip from the Persian Gulf to Western Europe, with the first leg of the journey being via Cape and the ballast leg via Suez. The model also considers the possibility of part loading. Thus it might be more profitable for a large tanker to load a part cargo from the Persian Gulf so as to enable it to transit the Suez Canal both on its way to Western Europe as well as on the return trip. The capacity lost because of the weight of the fuel bunkers that have to be carried is also taken into account as well as the time in port needed to load and unload cargo. The optimum speed is determined theoretically by utilizing the technological relationship between fuel consumption and speed. The relationship between fuel consumption and speed is roughly cubic and knowledge of this technological relationship allows the optimum speed to be determined theoretically for each ship type, as in Nortank.

2.8 Criticism of existing theories

2.8.1 Freight Market Consensus View

We have reviewed various past attempts to model the behaviour and interactions of the shipping markets. All these models, beginning with the pioneering efforts of Tinbergen and Koopmans down to the most recent ones, have very similar freight market structures. This is derived, explicitly or not, from the assumption of profit maximization of ships and instantaneous market clearing. Optimising behaviour implies that supply is proportional to the size of the fleet and is positively related to freight rates relative to fuel prices and operating costs.

The results of Tinbergen and Koopmans when compared with more recent freight market studies indicate that the empirical estimates of the elasticity of supply with respect to these variables are surprisingly stable over a time period of a hundred years. These empirical estimates also conform to the theoretical estimates derived from a priori knowledge of the production function of ships. Thus supply is considered to be very elastic at low levels of lay up while it becomes perfectly inelastic as lay up drops to zero and ships run at full speed.

Differences between the various empirical freight market models are not due to theoretical differences. They rather reflect the level of aggregation chosen and other practical difficulties of taking into account the effect on supply of other factors such as the waiting time in port and the length of the ballast trip. These factors are of minor importance since they are much less volatile over the cycle, so that at one extreme their effect on supply can be treated as a constant. On the demand side the common assumption is made that it is basically predetermined by factors exogenous to shipping and in most cases is assumed to be completely inelastic with respect to freight rates. The other common assumption made is that the freight market clears instantaneously. An isolated exception to this is Charemza and Gronicki (1981).

These widely held theoretical beliefs regarding the freight market structure, which are supported by the empirical evidence, leads to the following consensus view about the short term behaviour of freight rates. Freight rates depend positively on the freight market balance; that is the level of demand relative to the fleet. An increase in fuel prices or operating costs causes a shift of the supply curve to the left and this increases the equilibrium freight rate. During periods of depression, intersection between demand and supply occurs at the elastic region of the supply curve, then even wide fluctuations in demand will fail to have a significant impact on rates but they will mainly affect lay-up. During boom periods however where the inelastic demand meets supply in its inelastic region, even small changes in demand or the determinants of supply will lead to significant changes in freight rates and very little change in lay up.

2.8.2 Ship markets' diverging views

In contrast to the freight market, there is as yet no consensus view regarding the behaviour and interactions of the ship markets among themselves and with the freight markets. Thus the dynamic response of ship prices, shipbuilding, scrapping and consequently freight rates, to anticipated and unanticipated fluctuations in external factors is still a controversial issue. The lack of consensus is illustrated by the fact that there exist considerable differences in the the second hand, shipbuilding and scrapping market structures, among the various models examined in this chapter.

There are two basic reasons for this multiplicity of alternative structures. The first is that, in the majority of cases and in contrast to freight market modelling, the econometric specifications are not always consistent with optimizing behaviour. The second reason, which can be thought of as a particular manifestation of the first, is the arbitrary treatment of expectations of future market developments. In the case of shipping these are expected to be particularly important since the economic lifetime of ships can, depending on market conditions, exceed 20 years. Thus decisions in the second hand, shipbuilding and scrapping markets are expected to be strongly influenced by both short term and long term views.

The treatment of the demand for new and second-hand ships

Concerning the lack of theoretical foundations, this is particularly true for the demand side of the shipbuilding and second-hand markets. In almost none of the existing econometric models is the specified demand for new or second-hand ships derived either implicitly or explicitly as the solution of a constrained optimization problem by agents.

Yet, the fluctuations in the demand for new ships and its response to market conditions is generally considered to be one of the fundamental causes of the cyclical behaviour of shipping markets. This is embodied in the existing models of the shipping markets where, ever since Tinbergen's (1931) contribution, the demand for new ships has occupied a central position in the whole theoretical mechanism which simulates cyclical behaviour. Given its central position, any weaknesses in this part of the model will considerably affect the validity of its whole structure. This problem is compounded by the fact that demand is affected by expectations the treatment of which has been inadequate.

Typically - with the exception of Norship - there is no proper modelling of the interactions between second hand prices and expected profits and capital gains which determine the return on shipping investment. The latter is likely to be the major factor determining the demand for ships in the second hand market. Again here this problem is compounded by the fact that expectations are of crucial importance. There has also been little work done on the interactions between the second hand and newbuilding markets.

We also find that there are material differences in the specified supply of ships for scrap by the various models. The only area - apart from the freight market -

in which there is more or less widespread agreement is that of the supply of newbuildings. This is commonly specified to be proportional to the existing shipbuilding capacity and to move in line with the price of newbuildings relative to the price of factors used as inputs in the shipbuilding process.

The treatment of expectations

In cases where market expectations of a future variable, say freight rates, are believed to affect the supply or demand, these expectations have been typically - again here Norship is an exception[8] - assumed to be generated by an extrapolation mechanism of current and recent trends in various variables (including past rates) that would normally help to predict the future level of freight rates. This creates a schizophrenic situation in which the model's own predictions will in general not agree with those generated by the extrapolative forecasting mechanism imbeded in the model. This suggests that such models are likely to be unstable since if they purport to have explanatory and forecasting ability, the market would then tend to use the model's theoretical structure in order to form expectations and thus abandon the extrapolative mechanism which the model assumes it has been using. But in that case the model would no longer be valid as the expectations generating mechanism will have changed and will not be the same as the one imbeded in the model.

Yet, such models which assume that people forecast the future level of freight rates, profits and other variables by extrapolating recent trends or by using some other ad hoc backward looking forecasting rule, are capable of simulating shipping cycles. For example, an increase in demand will typically lead to an increase in freight rates and a reduction in lay-up which will then be projected to last for some time leading to an

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[8] See however our comments in the last paragraphs.

investment boom. This raises the growth rate of the fleet but while this lags behind the growth rate of demand, rates will be rising and the market will be becoming increasingly optimistic. This will reinforce the investment boom until suddenly the fleet expands faster than demand and freight rates begin to recede. This leads to a period of recession characterized by increasing levels of lay-up and falling levels of freight rates and prices. Pessimism returns to the market and investment begins to fall. As long as the growth rate of the fleet is maintained above that of demand, rates and prices continue to fall. That is, until the depression in shipbuilding brings the growth rate of the fleet down and rates stabilize or even begin to increase.

During this hypothetical cycle we find that shipping investors consistently and predictably overestimate future freight rates during the boom while the opposite happens at the bottom of the depression. This leads to a parallel predictable cycle of excessive positive returns during the upturn followed by negative returns on shipping investment as the market moves into the recessionary phase. This suggests that such models are likely to be unrepresentative of the real world since investors' behaviour should normally eliminate predictably high or low returns. In such models investors fail to foresee the effects of a shipbuilding boom/depression on future market conditions even though the writing is on the wall.

A 'new' theory of shipping markets

Chapter 3 presents a theory of shipping markets which contains some features which are new to the modelling of the shipping industry and which should therefore be pointed out. We attempt to remedy the above mentioned defects in the specification of demand for new and existing ships and the treatment of expectations. Regarding the former we utilise the suggestions of capital theory in order to model the behaviour of investors in the market for new and second hand ships.

Thus new and existing ships are treated as capital assets the portfolio demand for which varies in line with the expected return on shipping investment relative to the return on other investments. The expected return on ships consists, of course, of expected profits and capital gains.

Our assumption of economic rationality will also apply to the use of available information. It shall thus be assumed that expectations are rational. Thus speculation is ascended to a primary role. The assumption of rational expectations and forward looking behaviour generates a richer set of dynamics and speculative behaviour which do not appear in the conventional models. Rational expectations mechanisms, create strong links between the current level of prices and assumed future impulses from the environment, as informed speculation causes investors to take evasive action or bullish positions in order to eliminate the likelihood of excessive capital losses/gains. Thus the system does not only respond to current and past movements in the exogenous variables - as in conventional models - but also to perceived changes in the future level of the external factors. Such speculative behaviour, which is believed to be a central feature of the real world, does not appear in the models that have been reviewed. Existing models cannot distinguish between anticipated and unanticipated movements and generate identical forecasts whether the path of the exogenous variables is foreseen or not, something which is unlikely to be true in practise.

It shall be seen that the rational expectations model is capable of simulating cyclical behaviour in freight rates, lay-up, ship prices and fleet growth which does resemble the real world shipping cycle and in a way which is consistent with the assumptions of optimizing behaviour. A central position in this theoretical mechanism which generates the cyclical patterns, is occupied by the efficient speculative actions of investors. Thus booms in price and shipbuilding do not reflect belated and myopic response to current and lagged profits as in existing models. They rather reflect the forward looking behaviour of investors who immediatelly bid-up the value of ships and in the process cause an expansion in the supply of new ships, until the expectation of excess return is eliminated.

It will be seen that some aspects of our theory are very similar to that embodied in Norship and this calls for some additional comments and comparisons. Indeed our modelling of newbuilding and scrapping supply is very similar to that of Norship. In addition, both models assume that second hand and newbuilding prices reflect market's expectations of the future stream of profits.

However there are crucial differences in the treatment of these expectations as well as in the treatment of the demand for newbuildings. The differences in the latter will become clear in chapter 3 where the demand for newbuildings is analysed theoretically. Our rational expectations approach to the modelling of expectations of future profits say, is to endogeneise these by equating them to the model's prediction of future profits. Intuitively this should be a consistency requirement which reflects the fact that in a rational enviroment the forecasts of a correctly specified model - which purports to have explanatory and predictive ability - and the market's expectation should be the same. The loss of money that mistakes in expectations imply, create real world forces which should tend to equate market's expectations with those of a correctly specified model.

On the other hand Norship has modelled expectations of future profits in a different way but in the process has argued in circles. Expectations of long term profits can be calculated from the price of newbuildings the demand and therefore the price of which reflects expected long term profits. According to our model these relationship are valid but one of them is reduntant when newbuilding demand is correctly specified. In this case one of the relationships can be derived from the other by simply rearranging terms from the LHS to the RHS of the equation. We close the model by using the rational expectations assumption thereby creating speculative forward looking links by equating the expectation of long term profits with the model's prediction of the future stream of profits. On the other hand in Norship, the model is closed by specifying a theoretically flawed demand for newbuildings function. By partly solving the above relationships of Norship, it can be seen that at the end of the day the expectations of the model are backward looking. This is illustrated by the simulations of Norship reported in Table 2.3. Whereas - following the shock in bunker prices - profitability is lower from year 3 onwards, paradoxically prices are 1.3% higher in that year which is inconsistent with the model's prediction of a drop in future profitability.

CHAPTER 3

THE THEORY OF SHIPPING MARKETS

This chapter presents a 'new' theory of the shipping markets. Novel features of this theory is the treatment of ships as capital assets as well as the assumption of rational expectations. Section 2 presents the methodological approach to the problem of formulating the theory and give a short description of the theoretical model. Section 3 analyses the optimisation problem of various agents in various markets and derives the theoretical demand and supply curves which constitute the building blocks of the model.

The long run behaviour of the system is analysed in section 5. Section 6 presents a discrete time formulation of the model which is solved. Section 7 presents a continuous time formulation of the model. This is used in section 8, 9 in order to study both the short term and long run response of the markets to various types of anticipated and unanticipated shocks.

3.1 Introduction

In the previous chapter we reviewed past attempts to model the behaviour of the shipping markets. It was seen that there exist no substantial differences among the various freight market structures embodied in the various models[1]. In contrast to the freight market consensus, modelling of the markets in vessels has been a controversial subject. This is particularly true in the area of the demand for new and existing ships and of the role of expectations. It was argued that, typically, modelling of the markets for ships has been inconsistent with the assumption of rational optimizing behaviour.

In this chapter a 'new' theoretical model of the shipping markets is developed which is explicitly derived from assumptions of optimizing economic behaviour. This assumption will also apply to the treatment of expectations which will be endogenised so as to be consistent with the predictions generated by the model itself, as along the lines of the rational expectations hypothesis. Ships will be treated as capital assets the demand for which varies in line with the expected return on ships relative to the return on other assets. The return on ships consists of profits and capital gains.

Section 3.2 describes the methodological approach to the formulation of the model and gives a brief overview of the model. Section 3.3 looks at the microfoundations of the theory. It considers the objectives and constraints that various market participants face. It then analyses how their behaviour responds to changes in the environment as they aim to attain their objective. This constitutes the micro side of the theory. By aggregating the reactions of individual agents, total

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[1] This is true except for the isolated case of Charemza and Gronicki (1981).

market demand and supply curves are derived. These constitute the building blocks of the macro system.

Sections 3.4 to 3.8 consider the macro behaviour of the model. Section 3.4 considers how the system reacts in the long run to changes in the external environment. This ignores short term reactions and the path that the system follows in order to reach a new long run equilibrium.

The short term behaviour of the model is considered in sections 3.5 to 3.8. The model will be formulated both in continuous time and in discrete time. Section 3.5 presents a discrete time version of the model. The discrete time model will be solved analytically in order to derive an explicit reduced form expression that relates ship prices to current, lagged and expected future movements in the external factors.

Section 3.6 presents a continuous time version of the model. The continuous time model will be used in order to study the response of the shipping markets to both anticipated and unanticipated changes in the external factors. This analysis relies on the use of phase diagrams. The effects of unanticipated shocks are considered in section 3.7. It will be seen that freight rates, prices, shipbuilding and scrapping tend to overshoot their long run equilibrium values in response to demand or bunker price shocks. In contrast freight rates, prices and scrapping tend to undershoot their long run level in response to a shipbuilding cost shock while shipbuilding again overshoots. When a returns to capital shock occurs then prices, shipbuilding and scrapping overshoot while freight rates undershoot the long run equilibrium.

The effects of anticipated shocks are analysed in section 3.8. It will be seen that the shock has similar long run effects as if it had been unanticipated. However, the short term response is different.

The effects of these anticipated and unanticipated shocks will be analysed by means of theoretical simulations of the model which show how the market will react to various shocks from the external environment. The simulated paths exhibit cyclical patterns. Section

3.9 not only summarizes the results but also considers whether the simulated cycles resemble the empirical ones that were discussed in chapter 1.

3.2 Methodology

3.2.1 Micro and macro aspects of the theory

The model presented in the following sections is a mathematical representation of demand and supply relationships and equilibrium conditions in the various shipping markets. The model distinguishes between four different but interdependent shipping markets. These are the freight, second hand, shipbuilding and scrap market. The last three markets will be collectively referred to as the markets for ships. It aims to explain how freight rates and time charter rates, lay-up, optimum speed, new and second hand prices, shipbuilding and scrapping are determined in terms of various external factors that can operate directly either through the freight markets or the markets for ships. The external factors include the demand for freight, fuel prices, operating costs, laying-up costs, alternative returns to capital, shipbuilding costs, scrap prices etc.

The methodology of the theoretical approach is the following. Each of the four shipping markets is considered in turn with regard to a representative individual agent. Given his objectives, the variables under his control and the constraints he faces, we calculate how his behaviour will change with market conditions assuming he always wishes to attain his objective. For example, on the supply side of the freight market, the ship manager aims to maximize profits. Given his production function, freight rates and bunker prices, he varies the speed of the ship and other parameters under his control in order to achieve maximum profit. Similarly on the supply side of the shipbuilding market, the shipbuilder aims to maximize the present value of the yard, given the level of ship prices, shipbuilding costs and his production function, by choosing the optimum output level and the best combination of factors of production. On the supply side of the scrap market and the demand side of the newbuilding and second hand markets, the investor aims to achieve the best risk/return combination by varying the amount of ships and other assets in his portfolio, given the correlations and expected returns on each investment.

The analysis of the behaviour of individual economic agents is the micro side of the theory and this is presented in section 3.3. By aggregating the individual demand/supply generated by each agent, a set of interacting aggregate supply and demand functions in each market is derived. The way these interact in order to determine the equilibrium level of prices and quantities constitutes the macro side of the theory and this analysis is presented in sections 3.4 - 3.8.

3.2.2 Summary of model structure

A proper model of the shipping markets should at least distinguish between the tanker and dry cargo sectors. It is simpler however to begin the theoretical analysis by considering a simple model of a hypothetical shipping industry in which there exists only one ship type. This hypothetical industry will still consist of a freight, second hand, shipbuilding and scrapping market. We ignore all the inessential detail in order to facilitate understanding of the key interactions among these four markets, which give rise to the observed fluctuations and comovements in rates, prices, fleet growth etc. during the cycle. These key interactions also appear in identical form in the more complicated cases where there is more than one ship type. However in the latter case there are also important interactions among the various sectors that can lead to spillover effects from the one sector to another. These spillover effects cannot of course be studied in the one sector model presented in this chapter. They will be analysed by means of computer simulations in the following chapters were the econometric model is presented. This is based on a theoretical model which is really an extension of the simple model that is developed in this chapter, to the case were there is more than one ship type. The basic micro features and some of the implied macro characteristics of the simple model are the following:

Freight Market

The supply of freight services is directly proportional to the amount of ships trading multiplied by average speed after allowing for some inefficiency parameters such as waiting time in port and time spent in ballast or repairs. The technology of the ship is such that speed varies directly with fuel consumption. It will be assumed that the shipping company maximizes profits and it will be shown that this implies that optimum speed varies directly with freight rates relative to fuel prices. Thus the total freight market supply derived by aggregating over individual supplies is directly proportional to the size of the fleet and is positively related to freight rates but negatively related to bunker prices.

Demand on the other hand will be assumed to be completely inelastic with respect to freight rates and therefore it will be treated as exogenous. The freight market clears by means of freight rate adjustments so that demand always equals supply.

Second Hand Market

Investors can choose among various assets. Portfolio demand for ships varies directly with the expected return on ships relative to the return on other assets. The return on ships consists of the profit rate and the capital gain. Since asset demands are sensitive to small changes in expected returns, investors will be prepared to hold ships at equilibrium, only if the return on ships is similar to the expected return on other assets adjusted for risk.

Shipbuilding Market

Shipbuilders will be assumed to maximize profits in the current period. This is consistent with present value maximization if there is no intertemporal trade off between profits in different periods. This will imply that the supply of new ships depends on the ratio of newbuilding prices to the prices of the variable factors used in the production process. If, as is expected to be true in practice, there are costs of adjustment, then profit and present value maximization are not equivalent. Although our focus here is on profit rather than present value maximization, the conclusions are similar in both cases, namely, that supply of new ships depends on the ratio of newbuilding prices to the price of shipbuilding inputs. However, in the case of present value maximization there are some dynamic complications introduced. The latter however are not essential to the understanding of the interactions of the markets and the cyclical behaviour that they generate. Thus in this chapter we deal with the easier static case where there are no adjustment costs and so shipbuilders are assumed to maximize profits in each period.

Newbuildings and second hand ships are similar assets that should therefore command similar prices after allowing for time of delivery and vintage considerations. Newbuildings are ships for future delivery and thus their prices may be assumed to be determined in the same way as prices in futures markets. In this market there are not only producers and/or buyers of the product willing to hedge the risk of an unexpected change in the price but also speculators who can earn a return if the current futures price deviates from the expected future spot price. Speculation on newbuilding (futures) prices should guarantee that the newbuilding price cannot deviate from the expected future second hand (spot) prices, after adjusting for age and vintage effects, by more than a risk premium. The fact that little secondary trade in newbuilding contracts takes place - the speculator is usually the eventual owner (buyer) of the ship - does not invalidate the theory's implications.

Scrap Market

A ship is scrapped when it is worth more dead rather than alive. Its scrap value is determined by the given amount of metal in the ship times the scrap price. Its second hand value moves in line with the general level of second hand values and it is a decreasing function of age. The supply of ships for scrap should therefore depend on the age profile and the ratio of ship prices to scrap prices.

Market Structure

Perfect competition in all markets will be assumed throughout this and the following chapters. Conditions akin to the theoretical ideal of perfect competition are widely believed to prevail in the major sectors of the shipping markets except the liner services and possibly some minor specialized sectors. No shipowner controls a significant proportion of the total fleet[2] and this contributes to active competition in freight, second hand, shipbuilding and scrap markets. Shipowners and shippers compete actively for cargoes in the freight markets and rates can oscillate widely in very short periods of time should the underlying determinants of demand or supply change. There is also very active competition in the second hand market were prices also change very rapidly. On the supply side of the the shipbuilding market there are a large number of shipbuilders each controlling a small portion of capacity. Similar conditions prevail in the scrap markets.

The geographical mobility of ships also contributes

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[2] In the tanker market the major oil companies do control significant portions of the available capacity. The capacity controled by an individual company however is sufficiently small so as to make supply manipulation, that aims to increase price, non-profitable without collusion among players.

to the establishment of an environment conducive to perfect competition. This mobility makes entry into the market easier as governments are forced to compete in order to attract not only new but also existing shipping capital. This competition leads to lowering of taxes on shipping capital and other barriers to entry. On the other hand, international competition for existing capital is usually impossible in the case of physically immobile assets where governments can hinder entry or exit and create local markets by following narrow nationalistic policies. Even entry into the shipbuilding market is considered to be easy relative to the size of the capital costs involved. Indeed many developing countries choose entry into the shipbuilding market as an easy step towards industrialization.

The following section develops in more detail and rigour the model structure that has just been briefly described.

3.3 Microfoundations of the theory

In this section we take a very close look at the behaviour of market participants in a simple hypothetical shipping industry. To handle analytically the theoretical model a number of simplifying assumptions will be made. It has already been mentioned that there is going to be only one ship type in the hypothetical shipping industry. In reality of course there are various ship types, e.g tankers, dry bulk carriers, combined carriers, general cargo ships, containers, liquified gas carriers, car carriers, passenger ships etc. Within each category ships can be further distinguished according to their size, age, propulsion technology, cargo handling technology etc. In this chapter all these differences shall be ignored and not only shall it be assumed that there is only one ship type but also that all ships are identical. In particular it will be assumed that ships do not deteriorate with age so that old, younger and new ships are also identical. It shall also be assumed that there is perfect competition in the freight market as well as in the markets for ships both on the demand and supply sides.

These and other numerous simplifications do not distort the theoretical insights that we develop. What we aim at in constructing this theoretical model of the shipping industry, is to strip away detail and so develop a simple framework, that will allow us to grasp the general principles and forces at work which would have been obscured but by no means invalidated by the inclusion of detail. Thus the exclusion of detail does not affect in any way the fundamental conclusions of this chapter regarding the key interactions among the various markets. Instead, they facilitate a quick and rigorous derivation of the main results. Indeed it is our belief that too much attention to detail in past work has hindered the development of an integrated theoretical model. In the same spirit we shall work with simple and concrete log-linear functional forms rather than more abstract and difficult to handle mathematical demand and supply curves.

However, in the following chapters where we aim to develop a real world econometric model, the effects of factors that for analytical convenience and clarity are here ignored, will be taken into account where we deem this to be relevant.

3.3.1 Freight market

Our hypothetical freight market has the following characteristics. First ships are able to load and unload their cargo instantaneously so that the waiting time in port is zero. Then the carrying capacity of ships is constant and does not vary with weather and sea conditions or port draft restrictions. Ships are also assumed to be able to choose any speed from zero to infinity i.e. there are no technological restrictions which set a limit to the maximum and minimum speed other than that already specified. Finally ships find a full cargo at the port of discharge so that there is no time wasted in ballast. We assume that costs in lay-up are always prohibitively high so that this option is never considered. These simplifying assumptions will effectively imply that the output of the fleet is directly proportional to its speed.

The supply side

The supply side of the freight market is considered first. Ships produce transportation services measured in ton-miles which are sold for a price which is the freight rate measured in units of currency per ton-mile. The output of the individual firm is measured in ton-miles per unit time period. Since the carrying capacity of the ship cannot be varied the output of the firm is directly proportional to the speed. In reality of course the inputs required for the production of transportation services are fuel, labour, port services, maintenance etc. In the hypothetical industry port services are ignored. The only variable input will be fuel. Labour and other inputs will be treated as fixed. up. Total costs consist of variable costs and fixed costs. Of these, variable costs consist purely of bunker costs while wages, costs of maintenance etc. constitute the fixed (operating) costs. Fuel consumption will be assumed to vary with speed according to following formula:

$$B = \sigma^{a} \tag{1}$$

where

B = Bunker(fuel) consumption in tons per unit time period

σ = Speed in miles per unit time period

a = Technological constant parameter ($a > 1$)

The functional form of (1) is not only simple enough to handle analytically but it is also an accurate representation of the real world relationship between fuel consumption and speed, as has been determined from micro data. The assumption that $a > 1$ (which effectively implies that we have decreasing returns to scale) is theoretically necessary for the maximisation problem to have a finite solution. If $a < 1$ then we would typically find that it would pay to increase speed without bound and so there would not be a determinate solution to the profit maximisation problem. Again this assumption is not at all unrealistic as the engineering micro data suggests that $a = 3$.

Within a particular time period a ship earns a freight revenue which is equal to its output (as measured in ton-miles) times the freight rate per ton-mile. Since output is proportional to speed, freight revenue per unit time period can be written as follows

$$R = F\sigma \tag{2}$$

where

R = Freight Revenue per unit time period

F = Freight Rate in units of currency per ton-mile

Profit is the difference between revenue and costs and therefore it can be written as

$$\pi = F\sigma - P_b B - OC \tag{3}$$

where

P_b = Price of bunkers

OC = Fixed Costs (operating costs)

The time charter equivalent $\tilde{\pi}$ is defined as profits before fixed costs or revenue minus voyage costs and it is therefore given by the following expression

$$\pi = \tilde{\pi} - OC \tag{3'}$$

or

$$\tilde{\pi} = F\sigma - P_b B$$

Since B is a function of σ, (3) can be written as

$$\pi = F\sigma - P_b\sigma^a - OC \tag{4}$$

The objective of the shipping manager is to maximize the profit of the ship which is equivalent to maximizing the time charter equivalent since operating costs are fixed. Because of perfect competition, the individual firm treats freight rates and bunker prices as given so that profit maximization in this case is consistent with setting the derivative of (4) with respect to σ to zero. The derivative of (4) is

$$\frac{d\pi}{ds} = F - aPb\sigma^{a-1} \qquad (5)$$

Setting this equal to zero it can be seen that the optimum speed is given by the following relationship:

$$\sigma = (F/aPb)^{1/(a-1)} \qquad (6)$$

Hence, profit maximizing behaviour implies that speed varies directly with the ratio of freight rates to bunker prices. When freight rates increase it pays to increase the speed of the ship and incur the extra fuel costs since these will be more than compensated by the extra revenue. On the other hand when fuel prices increase it pays to reduce speed and economise on fuel costs because it more than compensates for the loss of freight revenue. Substituting expression (6) into (4) implies that maximum profit is related to freight rates and bunker prices according to the following formula:

$$\pi = k(F^{1+\gamma})/(Pb^{\gamma}) - OC \qquad (7)$$

where the constants γ, k can be expressed in terms of a as follows

$$\gamma = 1/(a-1)$$
$$k = a^{1/(1-a)} - a^{a/(1-a)}$$

Using (3') and (7) we find that the maximum time charter equivalent is

$$\tilde{\pi} = k(F^{1+\gamma})/(Pb^{\gamma}) \quad (7')$$

The amount of ton-miles supplied by the i^{th} individual ship is equal to its carrying capacity times the speed, i.e

$$q_i = K_i\sigma$$

where

q_i = Ton-miles supplied by the i^{th} ship

K_i = Carrying capacity in dwt of the i^{th} ship

To obtain the aggregate market supply we sum over all ships to derive the following relationship

$$q^S = K\sigma \quad (8)$$

where

$q^S = \sum_i q_i$ = Total market supply

$K_i = \sum_i K_i$ = Total carrying capacity of the fleet

Substituting (6), into (8) gives

$$q^S = K(F/aPb)^{1/(a-1)}$$

or by simply using the definition of γ

$$q^S = K(F/aPb)^{\gamma} \quad (9)$$

Thus the freight market supply function has been derived. It can be seen that it is directly proportional to the size of the fleet and moves in line with the changes in the ratio of freight rates to fuel prices. In the more realistic case were the proportion of time spent in port or in ballast is nonzero we would obtain a similar but more complicated relationship than (9). The main result derived here though would still hold, namely that speed is positively related to freight rates and negatively related to bunker prices.

The demand side

Perfect competition will be also assumed on the demand side of the market. Additionaly and in line with previous models of the freight markets, demand (q) will be treated as being completely inelastic with respect to freight rates so that it can be considered to be exogenous. There would be no analytical complications in incorporating a downward sloping demand curve into the model at this stage. However, the effects of bunker price shocks crucially depends on the elasticity of demand relative to that of supply. Allowing for the more general, elastic demand case would produce some ambiguity in the results of the following sections. In particular, following a change in bunker prices, profits might increase or decrease depending on whether and to what extent demand is elastic or not. It is preferable to deal only with the non-ambiguous and empirically relevant, inelastic demand case.

Freight Market Equilibrium

Freight rates will be assumed to be flexible enough so that the freight market clears within the selected time period. The equilibrium freight rate is then given by the intersection of the inelastic demand curve with the upward sloping supply curve.

$$q = q^S \tag{10}$$

$$\Rightarrow \; q = K(F/aP_b)^{1/(a-1)}$$

3.3.2 Second Hand Market

Portfolio theory typically assumes that investors prefer higher returns to lower ones but they also prefer less risk to more. If however returns on individual assets are uncertain and not perfectly correlated it would normally pay to diversify and hold assets that might offer lower expected returns but which can make the overall portfolio less risky. Sharpe (1964) proved that under such circumstances the equilibrium rate of return on a risky asset is equal to the return on a riskless asset plus a risk premium. In the case of shipping this suggests that:

$$r^S = r + \text{risk premium} \tag{11}$$

where

r^S = expected return on shipping

r = expected return on other investments

This section looks at three different hypothetical worlds each involving progressively more uncertainty and risk.

Case 1 : Zero uncertainty perfect foresight case

Case 1, will be the perfect foresight, zero uncertainty case. Here investors will only be prepared to hold ships if they offer a return which is at least as big as the return offered by other assets. On the other hand they will only be prepared to hold other assets if they offer a return which is at least as big as the return on ships. Since equilibrium in the asset markets requires that the demand for each asset equals the available supply and there will only be some demand for an asset if it offers a return which is at least as big as those offered by other ones, then there can only be an equilibrium when the returns on all assets are equal. This implies that the following simple relationship between r and r^S should be true

$$r^S = r \tag{11'}$$

The actual return on an asset is defined as the profit rate plus the percentage increase in its value. Thus the return on ships at time t is defined as follows

$$r_t^S = \frac{\pi_{t+1} + P_{t+1} - P_t}{P_t} \tag{12}$$

where

P_t = Price of ships at time t

and where we have taken end of the period ship prices. Substituting (12) in (11') gives

$$r_t = \frac{\pi_{t+1} + P_{t+1} - P_t}{P_t} \tag{13}$$

which can be written as

$$P_t = \frac{\pi_{t+1} + P_{t+1}}{1 + r_t} \tag{14}$$

This gives the equilibrium price which must be established, in order to bring the return on ships in line with the return on other investments, given also the market's expectations regarding the future level of profits and prices. Of course, in the perfect foresight case the market's expectations and the actual future outcomes coincide.

Case 2 : Uncertain environment with risk neutrality

In the slightly less restrictive case where there is uncertainty regarding the actual returns obtained but where returns on all assets are either perfectly correlated or where investors are not risk averse, there is no scope or desire for diversification. Again there will only be some demand for an asset if its expected return is at least as equal as the expected return on other assets. We therefore obtain a similar relationship to (13), but because in this case actual and expected outcomes might differ it should be written as follows:

$$r_t = \frac{E_t \pi_{t+1} + E_t P_{t+1} - P_t}{P_t} \tag{13'}$$

where $E_t X_{t+k}$ denotes the expectation at time t regarding the value of variable X at time t+k. The above relationship can be written as

$$P_t = \frac{E_t \pi_{t+1} + E_t P_{t+1}}{1 + r_t} \tag{14'}$$

which is similar to (14).

Case 3 : Uncertain environment with risk averse investors

In the most general case were returns are uncertain and not perfectly correlated while the usual assumptions regarding the investors attitude towards risk and return are still valid, it pays to diversify among various assets in order to reduce risk at the cost of losing some expected return. Given some additional assumptions it can be shown that the proportion of their wealth that investors would wish to hold in ships would be a function of the return on ships relative to the return on other assets. Mathematically this can be expressed as follows:

$$PK^d/W = F(\overset{+}{r^s}, \overset{-}{r}) \tag{15}$$

where

W = Wealth

K^d = Stock demand for ships

and where a plus or a minus over a particular variable indicates the sign of the partial derivative with respect to that variable. If (15) is solved for r^s gives:

$$r^s = F(\overset{+}{r}, \overset{+}{PK/W}) \tag{16}$$

where we have made use of the fact that at equilibrium the stock demand for ships K^d must equal the available supply K. This looks like (11) but there is a variable risk premium which can change with the size of the fleet. Thus investors will demand a higher risk premium in order to hold more ships. We can substitute the definition of r^S into (16) and solve for P_t to obtain:

$$P_t = F(\overset{+}{W_t/K_t}, \overset{+}{E_t\pi_{t+1}}, \overset{+}{E_tP_{t+1}}, \overset{-}{r_t}) \qquad (14'')$$

This indicates that starting from an initial equilibrium situation, an increase in expected future prices or profits which tend to raise the return r^S and create an excess demand for ships, will have to be associated at the new equilibrium with a higher current ship price which will bring the return r^S back into line with the return on other investments r, so as to eliminate the excess demand. On the other hand an increase in the size of the fleet will require, at the new equilibrium, investors to hold portfolios which are more heavily weighted towards ships and this requires a higher risk premium. Given the expected future profits, prices and other returns this can only be achieved by a reduction in the current price.

Fundamentals and 'bubbles'

We have looked at the various cases starting from a hypothetical world of zero uncertainty and moving on progressively to cases involving more uncertainty and risk. Case 1,2 are really special cases of 3. They all boil down to a relationship like (14) or (14') or (14'') which mathematically are very similar. Both (14), (14') or (14'') are first order difference equations in P_t. An econometric version of equation (14'') will be finally incorporated into our econometric model.

Since this is new to the area of econometric modelling of shipping markets and one of the distinguishing features of our models it deserves a closer look. Even though we shall in the future work with (14''), here we investigate some of its properties by looking at (14), because it is simpler while at the same time it is mathematically similar and incorporates the same economic ideas. It can easily be shown that if we treat π_{t+k} as given and if it is assumed for simplicity that r is constant over time, then a possible solution of (14) is the following

$$P_t = \frac{\pi_{t+1}}{1+r} + \frac{\pi_{t+2}}{(1+r)^2} + \frac{\pi_{t+3}}{(1+r)^3} + \frac{\pi_{t+4}}{(1+r)^4} + \ldots \tag{17}$$

which is a well known result. However this is not the only possible solution that will satisfy (14). There exist an infinity of solutions which are all of the form

$$P_t = A(1+r)^t + \frac{\pi_{t+1}}{1+r} + \frac{\pi_{t+2}}{(1+r)^2} + \frac{\pi_{t+3}}{(1+r)^3} + \frac{\pi_{t+4}}{(1+r)^4} + \ldots \tag{18}$$

where A can be any real number. Equatiom (17) is a special case of (18) derived by setting $A=0$. Thus there seems to be a problem of non-uniqueness of solutions. If $A\neq 0$ then the solution diverges to plus or minus infinity. However, if the additional assumption is made that real asset prices can only fluctuate within finite bounds (as is obviously the case) the initial condition $A=0$ must be imposed. Accordingly we obtain a unique solution which is (17). Indeed (17) is the only solution that expresses prices purely as a function of economic fundamentals while cases where $A\neq 0$ have been interpreted to correspond to "speculative bubbles".

Take for example an asset that gives zero profit for ever. Mathematically its price can still be positive but since it gives no profit its price must keep growing at the rate r indefinitely in order to give a return in every period. The only stable solution is for its price to be zero for ever as (17) would indicate. We shall come across these unstable solutions later on but the theory of "Rational Expectations" suggests that these unstable solutions can be ignored and that the system has a unique stable solution.

3.3.3 Shipbuilding Market

Supply of new ships

Shipbuilders are assumed to maximize profits per unit time period. This is consistent with present value maximization if there is no intertemporal trade off between profits over different periods. Shipbuilding will be assumed to be a perfectly competitive market and thus each shipbuilder will treat the value of newbuildings P_n as given. The constraint that each shipbuilder faces is the production function which is a mathematical representation of the relationship between the amount of various inputs used (such as labour, metals, energy, land etc.) and the volume of output obtained. Maximising profit subject to the production function can be shown to imply that the optimum level of shipbuilding output will be related positively to the price of new ships and to the amount of fixed factors employed but negatively to the price of variable inputs. This relationship can be represented mathematically by a function of the following form:

$$D = F(\overset{+}{P_n/P_1},\ \overset{+}{P_n/P_2}, \ldots,\ \overset{+}{P_n/P_m}; Z_D) \qquad (19)$$

where

D = Shipbuilding output

P_n = Price of newbuildings

and where P_1, P_2, ..., P_m denote the prices of the variable inputs required in the shipbuilding production process, and Z_D is a vector of exogenous variables that influence the supply of new ships. For example in the simple case were there is only one variable factor say X_1 and where X_1 is related to D according to the following inverted production function

$$X_1 = k_1 D^b \qquad (20)$$

where

k_1, b = technological constant parameters

then in this case the profit maximizing level of output is related to P_n, P_1 as follows:

$$D = k_2(P_n/P_1)^d \tag{21}$$

where

$d = 1/(b-1)$
$k_2 = (1/(k_1 b))^{1/(b-1)}$

If there are diminishing returns to the variable factor, i.e. $b > 1$, (22) implies that the supply of newbuildings varies directly with their relative price.

Newbuilding Prices

The way newbuilding prices are determined is now considered. A distinction should be made between quoted newbuilding prices and 'effective' newbuilding prices. Very often shipbuilding contracts are clouded in secrecy so that the quoted newbuilding prices are not the same as the 'effective' price that the owner pays. Various terms in the shipbuilding contract, e.g cheap finance or subsidy, might actually reduce the 'effective' newbuilding price paid by the owner below that quoted by the builder. It is the sometimes unobservable 'effective' price that is here considered to be the newbuilding price that the investor pays and which the builder receives. It is this that affects market behaviour, and not the quoted price.

Empirically we can observe a close correlation between newbuilding and second hand prices. This is not surprising since newbuildings and existing ships are similar assets once allowance is made for vintage, age and delivery. In the extreme case were ships do not deteriorate new and second hand ships are identical. Let us distinguish between new ships and newbuildings. New ships will be considered as those ships which have just been produced and therefore they are immediately available to trade. They can be sold at a price which is the same as the second hand price since new and old ships are identical in our hypothetical shipping industry. Newbuildings on the other hand are not for immediate delivery but they can only be delivered after the construction period has elapsed. For the purposes of the analysis newbuildings are new ships for forward delivery.

We shall consider two cases. First we shall look at the case were newbuildings can be delivered instantaneously and then we shall look at the case were newbuildings can be delivered only after a non zero construction period has elapsed.

Case 1 : Instantaneous delivery

In the first case where the construction period is zero and where newbuildings can be delivered instantaneously there is effectively no difference between newbuildings and new ships. Thus the price of newbuildings must equal the price of new ships. The latter however are identical to, and are sold at the same prices as, second hand ships. Thus in this extreme case the price of newbuildings Pn must equal the second hand price P.

$$Pn = P \tag{22}$$

Case 2a : Non zero construction period in perfect foresight enviroment

Let us now look at the case were newbuildings are strictly for future delivery. Let us say it takes k years to deliver a ship. Assume an order is arranged for the newbuilding at time t and the price agreed to be paid on delivery is Pn_t. Assume also that there is perfect foresight and zero uncertainty regarding the future level of ship prices. Then Pn_t must be equal to P_{t+k}, that is the newbuilding price must equal the perfectly foreseen price of second hand ships (which are identical to new) at time t+k. This is because if Pn_t is higher than P_{t+k} then the investor could do better by waiting k years and buying an identical ship from the second hand market.

Thus investors will never accept prices higher than the correctly foreseen future price of ships P_{t+k}. On the other hand if Pn_t is less than P_{t+k} there will be an infinite demand for newbuildings since buyers could then make a guaranteed capital gain at time t+k by paying Pn_t to the shipbuilder and reselling for P_{t+k} at the second hand market. There can only be an equilibrium therefore when newbuilding prices are equal to the perfectly anticipated future value of new ships. Thus newbuilding prices are related to the second hand values by the following formula:

$$Pn_t = P_{t+k} \tag{22'}$$

In the previous paragraph it was seen that the demand for new ships is infinitely elastic at the correctly anticipated future price of second hand ships. An analogous result holds for case 1 were delivery is instantaneous. There demand for newbuildings is infinitely elastic at the point were newbuilding prices are equal to second hand values. This explains why past attempts to estimate downward sloping newbuilding demand curves have failed as for example in the case of Hawdon (1978). Demand for assets tends to be infinitely elastic at the equilibrium price. It will take a small change in price above or below the equilibrium level to turn the asset from being expensive into a bargain. These small price changes create massive market inflows and outflows guaranteeing that all the newbuildings supplied will be absorbed at the competitive price.

This simple analysis revolutionises the specification of the demand for new ships. This has been one of the weakest and theoretically least satisfying part of existing models. A downward-sloping demand for new ships does not exist and cannot therefore be estimated. Instead, demand is infinitely elastic at the equilibrium newbuilding price. Production of new ships (or in other words investment) is determined from the supply side in terms of the amount yards wish to supply at the equilibrium price which investors are prepared to pay. A small discount in price will create massive demand for the cheap asset. Thus all the supply is absorbed by the infinitely elastic speculative demand.

Case 2b : Non zero construction period in an uncertain environment with imperfect foresight

Let us look now at a further case where there is still a non zero construction period and where in addition there is some uncertainty so that foresight is not perfect. Here too, speculative considerations should ensure that newbuilding prices arranged at time t cannot deviate from the current expectation regarding second hand prices at time t+k by more than a risk premium. Higher prices than this will lead to massive withdrawal of investors from this market while lower prices will bring a massive increase in the demand for newbuildings. This suggests that in the more general case where newbuildings are strictly for future delivery and where there is some uncertainty, demand for newbuildings will be almost infinitely elastic at the expected future second hand price minus the risk premium. We therefore obtain the following relationship between newbuilding and expected second hand prices.

$$Pn_t = E_t P_{t+k} + k_3 \qquad (22'')$$

where

k_3 = risk premium

Our theoretical view is therefore that newbuildings' prices are set in a similar way *as if* there were fully efficient futures markets where builders, end users and speculators could buy and sell newbuilding contracts. Thus newbuilding contracts or orders are considered as instruments that efficiently allocate the risk of an unexpected drop in the price of ships from a single company (the shipbuilder) to the various investors who have agreed to buy the newbuildings. The fact that very little secondary trading in existing newbuilding contracts seems to take place does not necessarily deny the existence of market forces that move newbuilding prices to the level suggested by the theory. All that is required for the theory to hold is that when the outlook regarding the future market prospects and future second hand values changes, every investor changes his selling or buying price for newbuildings according to the new expectations. Thus newbuilding prices at which deals can be made change even though no actual trading takes place. Everybody agrees that newbuildings are now worth more or less and any new sales will have to be made at the new prices.

We rarely observe shipbuilders building a ship without having first secured an order contract for it. It is conceivable (and it occasionally occurs) that ships are build 'on spec' without a contracted order. When ready they are simply sold in the market for a price similar to that at which relatively new ships are exchanged for in the second hand market. This again emphasises the futility of estimating newbuilding demand functions. New ships can be built without orders.

When production is undertaken on a speculative basis, the shipbuilder faces the considerable risk of an unexpected drop in the price of ships. Given the long gestation lag inherent to shipbuilding the chances of such an event are considerable. The cost of an unexpected fall in values would be enormous. Under conditions of such risk, futures markets are likely to emerge that help to diversify these risks. It is natural therefore that shipbuilders should try to share some of these risks with other investors by arranging order contracts. It is perhaps due to the fact that the word 'order' has demand connotations that there have been misguided attempts in the past to estimate downward sloping newbuilding demand curves.

Finally, in this second case where delivery is not instantaneous, equation (19) has to be modified slightly in order to take account of the delivery lag. Equation (19) was derived from an analysis which assumed that ships can be delivered within the unit time period. Here however where there is a delivery lag, Pn_t affects the planned future supply of new ships i.e D_{t+k}. Similarly current deliveries are determined by past plans which were based on the price Pn_{t-k}, where k is the delivery lag. Thus for the particular case where it takes k year to deliver a ship (19) should be written as

$$D_t = F(P_{nt-k}/P1_{t-k}, \ldots , Pn_{t-k}/Pm_{t-k}; ZD) \qquad (19')$$

3.3.4 Scrap Market

A ship is scrapped when its scrap value exceeds its trading value. Its scrap value is determined by the amount of metal in the ship times the scrap price per ton. Its trading value depends on the expected profitability of ships and thus moves in line with the general level of second hand values. The supply of ships for scrap is hypothesized to move in line with the ratio of scrap prices relative to second hand values. The supply of ships for scrap should also depend on the age profile but for the present we abstract from such considerations. Thus we propose that the supply of ships for scrap is of the following form:

$$S/K = F(Ps/\bar{P}) \qquad (23)$$

where

S = Dwt of ships scrapped

Ps = Price of scrap

Finally, the following identity is needed to close the model. The change in the fleet is simply the difference between shipbuilding deliveries and scrappings.

$$K_t = K_{t-1} + D_t - S_t$$

or

$$\Delta K_t = D_t - S_t \qquad (24)$$

where ΔX_t is shorthand notation for $X_t - X_{t-1}$.

Our models will consist of versions of equations (7), (9), (10), (14′), (19), (22′), (23) and (24).

3.4 Long Run Analysis

In this section the behaviour of the system at the long run steady state is analysed. This is a state where all the endogenous variables grow at a constant rate. In particular the fleet grows at the same rate as demand while real prices, freight rates and profits are constant. The analysis considers how the steady state long run equilibrium is affected by permanent changes in the exogenous variables. The steady state would eventually arise in the hypothetical case where all exogenous variables have stabilized or grow at a constant rate. Of course the system is never at a steady state because the exogenous variables continuously fluctuate, sometimes unpredictably. The analysis also limits itself to changes in the long run equilibrium that arise from a permanent change in an exogenous variable. For the present we do not however discuss how the market moves towards the new long run equilibrium. Thus its scope is quite limited for studying shipping cycles because as shown in the following sections major fluctuations are short run in character. However the long run analysis is simpler to analyse because the system becomes recursive. In addition the analysis is useful for analysing where the system is likely to settle following a major change in an exogenous variable which can be considered more or less permanent. It can be used for comparing the average state of the market across different decades or longer.

3.4.1 Steady State

The steady state is a state where all variables grow at a constant rate. In particular some variables such as real freight rates and prices might grow at a zero rate i.e. they are constant at the steady state. It would eventually arise when all the exogenous variables such as the growth of demand, the level of fuel prices, shipbuilding costs, scrap prices and alternative returns to capital have settled at a particular level. The equations describing the stationary system are the following

$$\Delta q = \Delta K \tag{25}$$

$$q = K + \gamma F - \gamma P_b \tag{26}$$

$$\pi = (1+\gamma)F - \gamma P_b \tag{27}$$

$$P = \pi - r \tag{28}$$

$$D = \mu_1 P_n - \mu_1 P_1 \tag{29}$$

$$P_n = P \tag{30}$$

$$S = -\mu_2 P + \mu_2 P_s \tag{31}$$

$$\Delta K = D - S \tag{32}$$

where all equations are in logarithms and where all time subscripts have been dropped from all variables since they are constant in the steady state. The first equation states that at the steady state the growth rate of the fleet equals the growth rate of demand. The second equation is equation (9) where we have substituted q for q^S on the left hand side since at equilibrium the two are equal. The third equation is simply equation (7) in log linear form where we have here and in all remaining equations dropped all nuisance constants in order to simplify the notation. Equation (28) has been derived from equation (13) by setting $P_{t+1} - P_t = 0$, which is true in the steady state, and then simply taking logarithms. Equations (29), (31) are log linear versions of equations (21) and (23). It is assumed for simplicity that equations (29) and (31) pertain to deliveries and scrappings expressed as a percentage of the existing fleet. Thus here and for the rest of this chapter D and S represent the delivery and scrapping rates. This allows us to derive (32) from (24), (29), (31). Equation (30) is the long run version of equation (22).

The system of equations (25)-(32) is recursive. To determine the level of ship prices in the long run substitute (30) into (29) which gives

$$D = \mu_1 P - \mu_1 P_I \tag{33}$$

Use (33) and (31) to substitute for D, S in (32) to derive the following

$$\Delta K = \mu_1 P - \mu_1 P_I + \mu_2 P - \mu_2 P_S \tag{34}$$

By using (25) to substitute for ΔK in (34) and then solving for P gives

$$P = (1/(\mu_1 + \mu_2))\Delta q + (\mu_1/(\mu_1 + \mu_2))P_I + (\mu_2/(\mu_1 + \mu_2))P_S \tag{35}$$

This is the reduced form solution for the long run equilibrium second hand price. It can be seen that the long run growth rate of demand, shipbuilding costs and the price of scrap have a positive effect on the long run value of ships. A higher growth rate of demand in the long run implies a higher growth rate of the fleet. The latter can only be achieved by an expansion in shipbuilding and a reduction in scrapping. These however require higher ship prices. Thus prices must rise in the long run. On the other hand if either shipbuilding costs or scrap prices increase this has a negative influence on the growth rate of the fleet. However in the long run the fleet must grow in line with demand. This requires compensating increases in ship prices that will cancel the restraining effects of a higher P_I or P_S on the growth rate of the fleet. These ideas are expressed by equation (35).

It can be seen that fuel prices and alternative returns to capital do not influence the price of ships in the long run, although as shall be shown later, they do in the short run. In order to derive the reduced form for the long run level of prices, no use was made of equations (26), (27) and (28). The first two equations represent the supply of freight services and the relationship between maximum profits and market conditions. These are implied by profit maximization and reflect the technology of transportation by ships. Equation (28) reflects investors' behaviour. These three equations play no role in the determination of the long run level of prices. Freight market supply shocks and interest rate shocks have significant effects on short term fluctuations of prices. In the long run, however, such shocks have no impact on values as the fleet adjusts.

To determine the level of prices in the long run, it is merely sufficient to know the long run growth in demand and the position of the shipbuilding and scrapping supply functions. Equilibrium prices are then determined by the requirement that the fleet must grow in line with demand. Values must move to that level which will induce sufficient newbuilding supply and scrapping reductions so that fleet and demand grow in parallel to each other.

In turn profits in the long run tend to the level that will allow investors to earn a competitive return (r) at the equilibrium price. In order to calculate the profitability we use (35) to substitute for P in (28). This gives

$$\pi = (1/(\mu_1 + \mu_2))\Delta q + (\mu_1/(\mu_1 + \mu_2))P_I + (\mu_2/(\mu_1 + \mu_2))P_s + r \qquad (36)$$

It can be seen that profitability is positively affected in the long run by the growth rate of demand, the cost of shipbuilding inputs, scrap prices and alternative returns to capital. We have already shown that the first three factors cause higher prices in the long run. Investors will only pay these higher prices if profitability increases. A higher r cannot affect prices in the long run but will increase profits eventually so as to raise the return on ships to the competitive level.

In turn this higher profit rate will only be achieved if freight rates increase. To derive the long run freight rate use (36) to substitute for π in (27). Then solve for F and this will give

$$F = [(1/(1+\gamma))(1/(\mu_1 + \mu_2))\Delta q + (\mu_1/(\mu_1 + \mu_2))P_I + (\mu_2/(\mu_1 + \mu_2))P_s + r] + (\gamma/(1+\gamma))P_b \qquad (37)$$

It can be seen that long run freight rates are positively related to the growth rate of demand, cost of shipbuilding inputs, scrap prices, alternative returns to capital and fuel prices. The first four factors imply higher profits in the long run as (36) shows. The fuel price does not affect prices or profits in the long run. But it brings a change in short term profitability that will require compensating changes in the freight market balance so as to bring the return on the long run price back to competitive level. To derive the long run freight market balance (which has been defined as the ratio between demand and the fleet and which indicates the extent of slow steaming) substitute (37) into (26) and solve for $q - K$.

$$q - K = [(\gamma/(1+\gamma))(1/(\mu_1 + \mu_2))\Delta q + (\mu_1/(\mu_1 + \mu_2))P_I + (\mu_2/(\mu_1 + \mu_2))P_s + r] - (\gamma^2/(1+\gamma))P_b \qquad (38)$$

Thus the ratio between demand and the fleet which we call the freight market balance is positively related in the long run to the growth rate of demand, cost of shipbuilding inputs, scrap prices, and alternative returns to capital but negatively related to fuel prices. An increase in any of the first three factors requires a higher level of prices so as to keep the growth rate of the fleet in line with that of demand. Higher prices however require higher profits and thus freight rates. For given fuel prices this can only be achieved by improvements in the long run freight market balance. A higher r implies higher π which also requires an improvement in the freight market balance. On the other hand an increase in fuel prices reduces the freight market balance in the long run but leaves profits unaffected. This is because the higher fuel price produces an independent tightness in the freight market by restraining supply and this tends to raise freight rates and profits. The negative effect of the lower freight market balance on profitability is exactly cancelled out by the positive effect of the higher fuel price thus leaving profits the same in the long run.

It can be seen that in order to determine the long term market equilibrium the system becomes recursive. The shipbuilding and scrapping equations determine the price level that will keep the growth rate of the fleet equal to that of demand. Then the portfolio balance equation determines the long run profit rate consistent with yields on competitive assets. The profit function determines the level of rates that will ensure that these profits will be earned. Finally the freight market supply function determines the freight market balance competitive with this equilibrium freight rate. It should be mentioned that the system of equations which are used in order to determine the long run equilibrium, would no longer be recursive if a more general version of equation (28) had be used which allowed for risk premia that could vary with the size of the fleet. The system is recursive only if there is zero risk or if investors are risk neutral or if the risk premium were constant. The real system however is likely to be close to being recursive since in reality and especially in the long run, changes in the risk premium brought about by endogenous changes in the size of the fleet are likely to be small.

The same ideas can be easily analysed in terms of four simple diagrams. Fig. 3.1 shows the various long run relationships. In quadrant I we depict the relationship (line SS) between the long run growth rate of the fleet and ship prices exactly as suggested by equation (33). The curve is drawn for given scrap prices and shipbuiding costs. An increase in either of the two will shift the curve to the right. In quadrant II we depict the relationship (line OR) between profits and

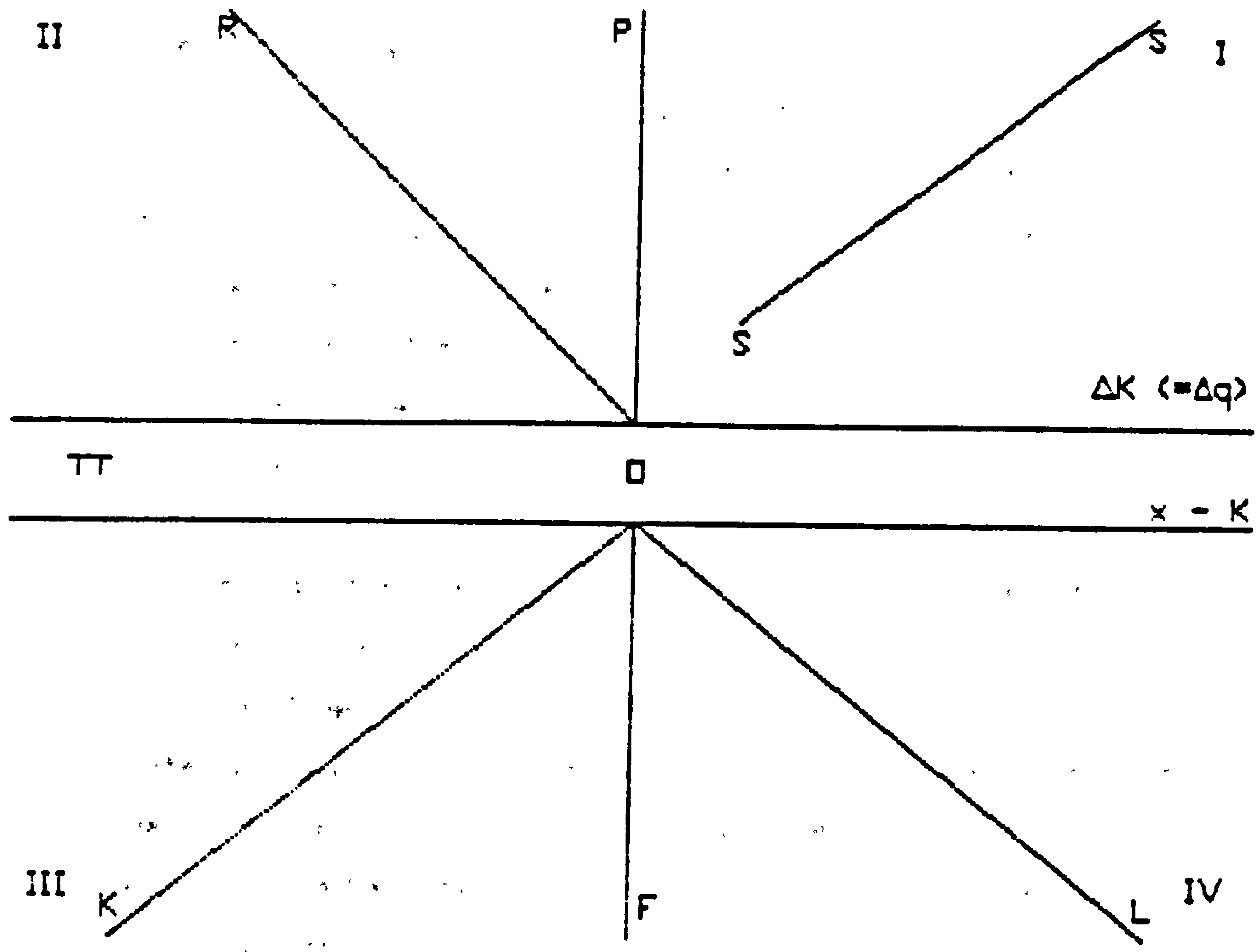

Fig. 3.1 : Long run relationships

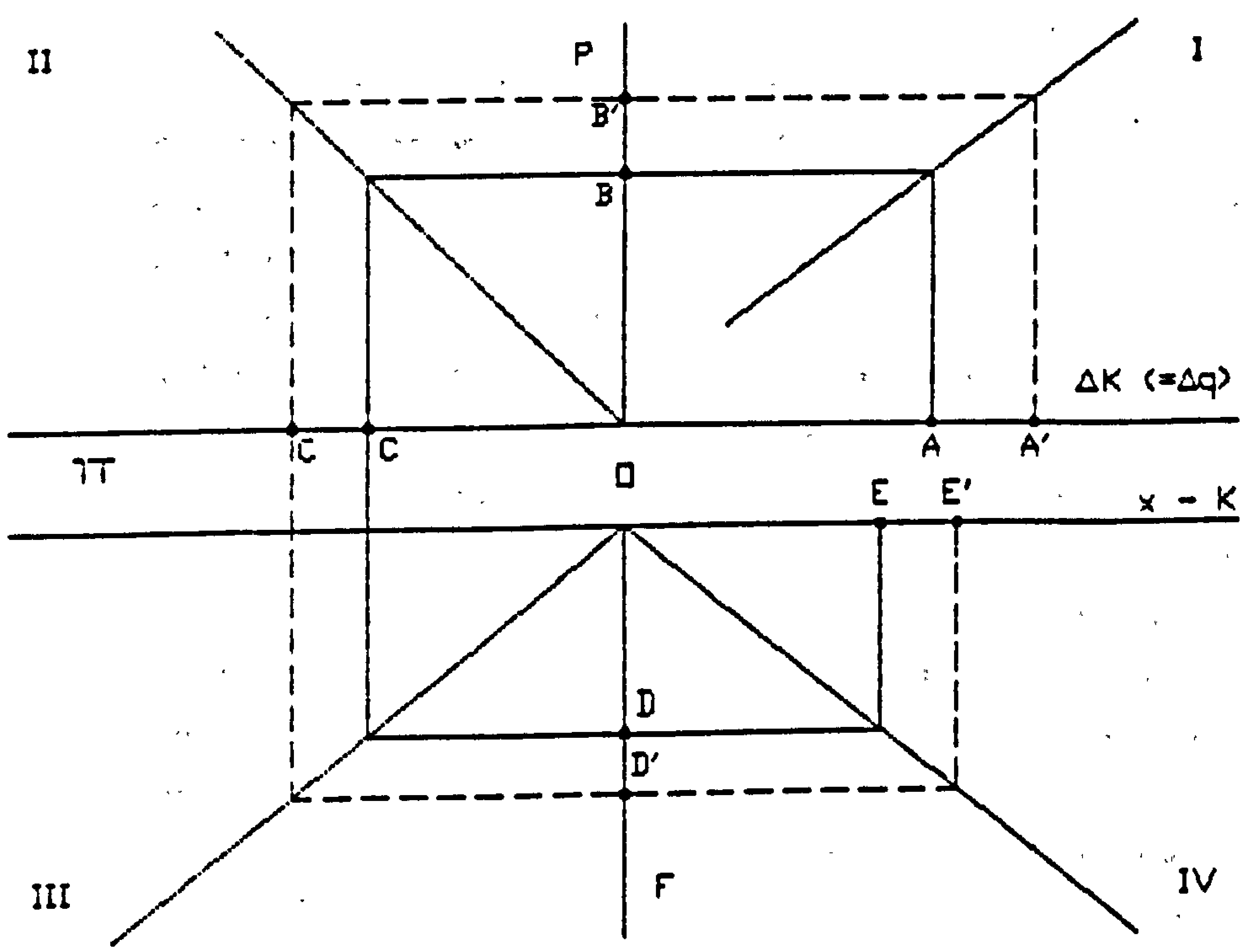

Fig. 3.2 : Effect of an increase in demand growth rate

prices in the long run and for a given r exactly as suggested by equation (28). Quadrant III shows the relationship (line OK) between profits and freight rates for given bunker prices as expressed by equation (27). Finally quadrant IV shows the relationship (line OL) between freight rates and freight market balance in the long run for given fuel prices.

Given the values of the exogenous variables the positions of the various curves are completely determined. The system is recursive. To find the solution of the system we make use of the fact that in the long run the growth rate of demand Δq equals the growth rate of the fleet. Let point A represent this long run growth rate on Fig. 3.2. The long run values of the remaining variables can be determined by starting from point A and moving alternately horizontally and vertically in anticlockwise direction. Thus B is the long run equilibrium level of ship prices which will cause the fleet to grow in line with demand. C is the long run level of profits which the market will have to offer in order for investors to be prepared to pay the price OB. D is the long run level of freight rates and E is the long run level of the freight market balance which will be consistent with a profitability OC. Notice that an increase in demand from A to A' will eventually increase ship prices to B', profits to C', freight rates to D' and the freight market balance to E'.

The effect of an increase in other exogenous variables can be determined in a similar way after repositioning the curves in the quadrants that have shifted as a result of the exogenous change. Thus an increase in the cost of shipbuilding or scrap prices will shift the position of the curve in quadrant I of fig. 3.3 to the left from SS to S'S'. Fig. 3.3 shows the new long run equilibrium that arises following such an exogenous shock.

The curve S'S in quadrant I represents the new long run relationship between ΔK and P, after the increase in costs or scrap prices. The long run growth rate of the fleet is the same, being equal to the unchanged long run

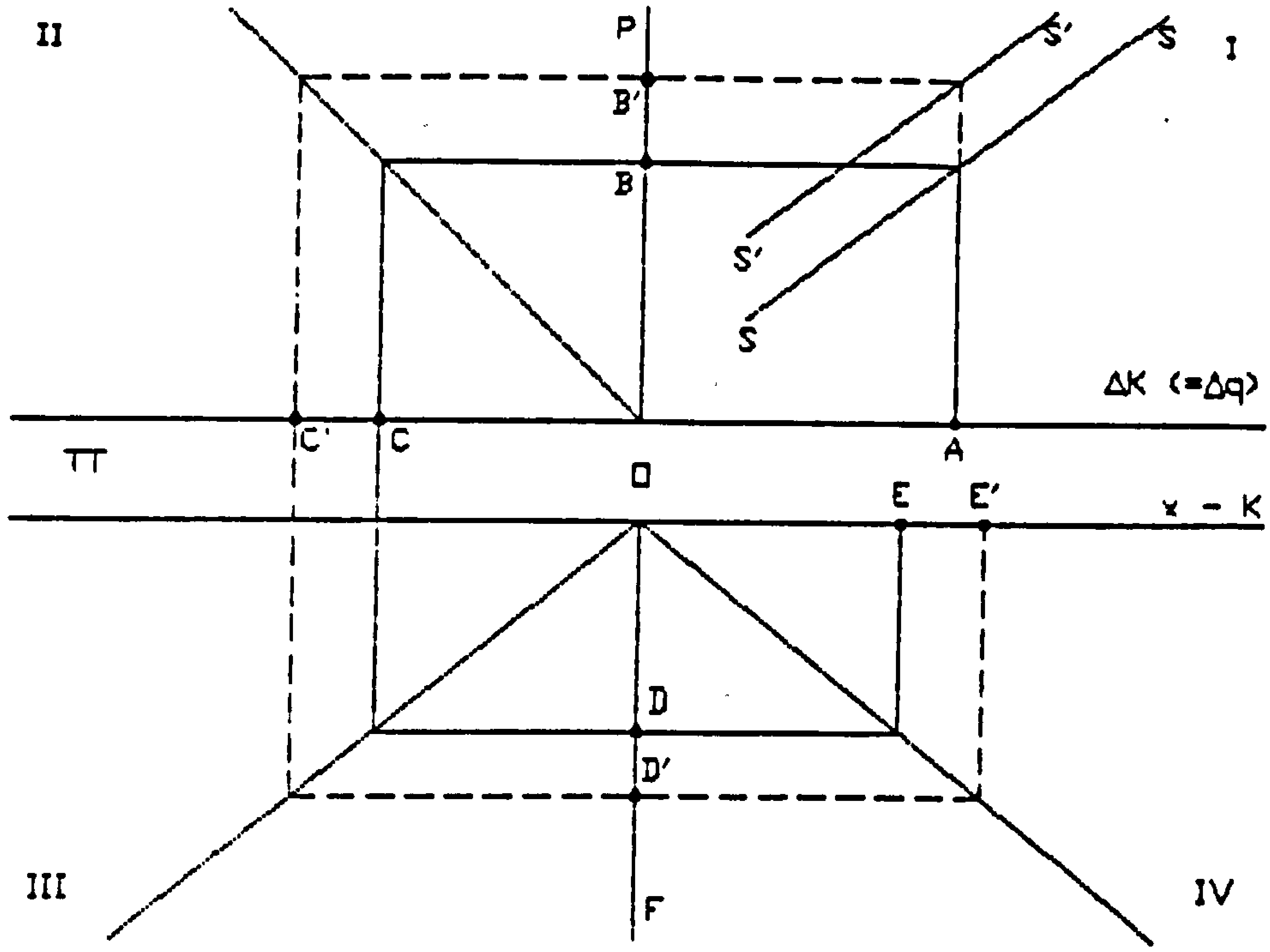

Fig. 3.3 : Effect of an increase in shipbuilding costs

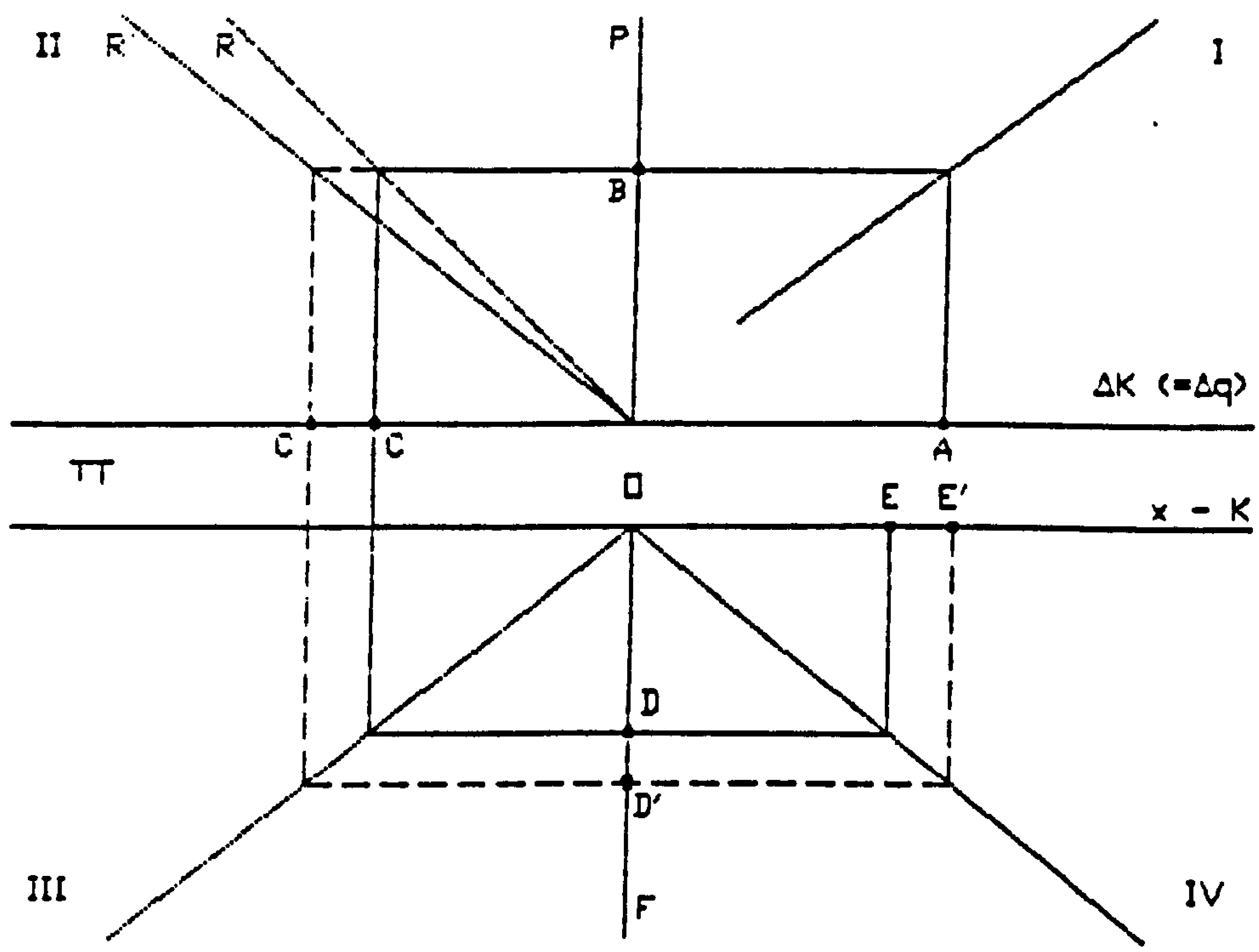

Fig. 3.4 : Effect of an increase in returns to capital

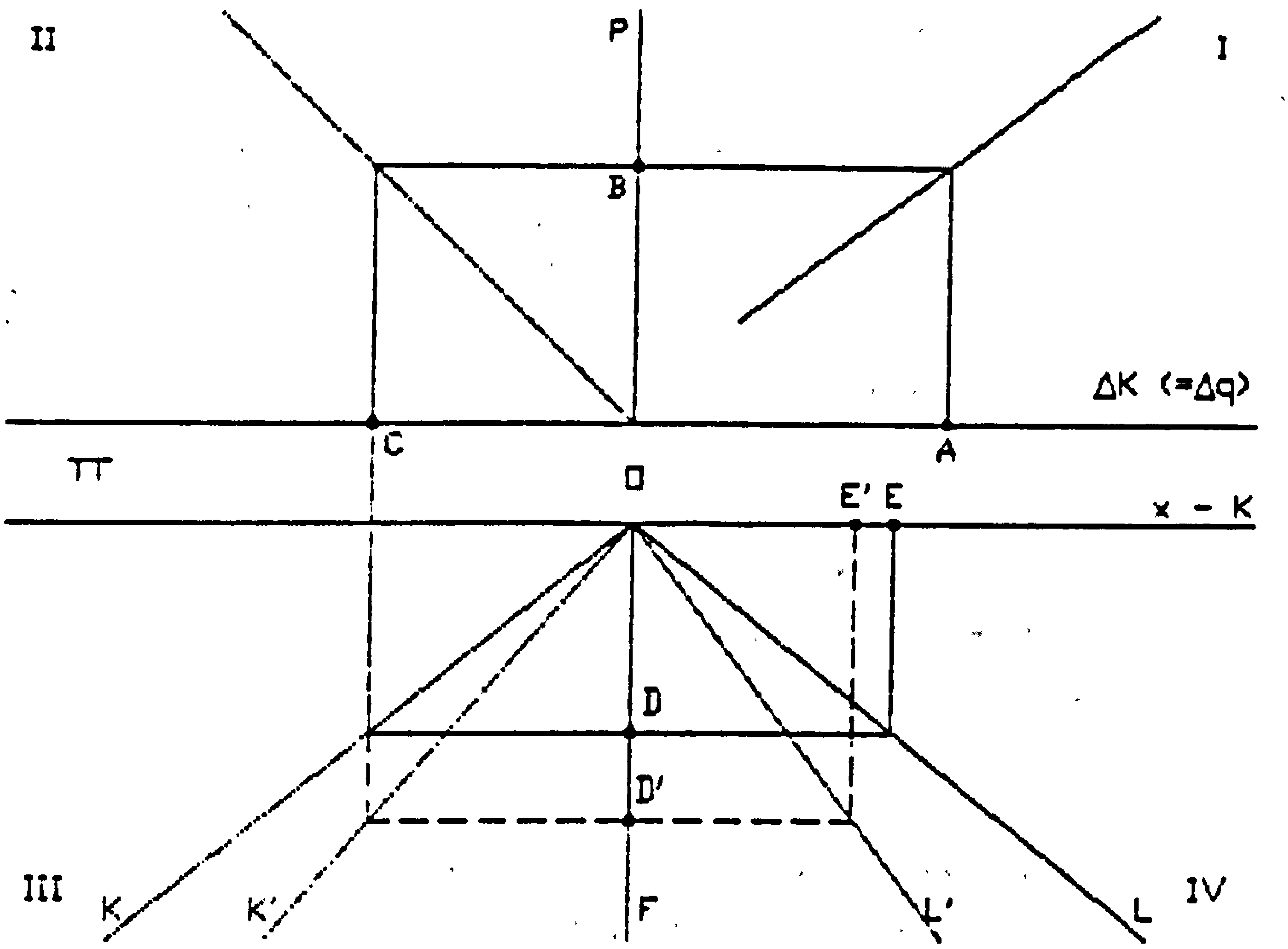

Fig. 3.5 : Effect of an increase in bunker costs

level of demand growth rate. However, because the higher shipbuilding costs or scrap prices have a negative effect on the growth rate of the fleet, this requires compensating increases in long run values. In turn this necessitates higher long run profits, and thus higher freight rates and an improved freight market balance.

In a similar way the effects of other exogenous shocks can be determined. An increase in r for example will shift the position of the curve in quadrant II downwards from OR to OR′ say, as in Fig. 3.4. This will not have any impact on long term ship values but will raise long term profitability, rates and market balance.

An increase in bunker prices will shift the curve in quadrant III to the right from OK to OK′ and the curve in quadrant IV to the left from OL to OL′, as shown on Fig. 3.5. This will not affect the long run level of prices and profits, but will lead to an increase in rates from D to D′ and a fall in freight market balance from E to E′. In order to maintain profitability where prices will be firm enough to raise the fleet in line with demand, long run freight rates must increase from D to D′ so as to offset the increase in costs. Because of higher bunker prices there is increased long run slow steaming and this manifests as a reduction in the freight market balance from E to E′.

3.5 Discrete time model (Analytic solution)

In this section a discrete time model is formulated using the theoretical ideas developed in section 3.3. This can be used in order to determine the short run fluctuations of prices and other variables. This dynamic model consists of the following discrete time versions of equations (7), (9), (10), (14′), (19), (22′′), (23) and (24).

$$q_t = q_t^s \tag{39}$$

$$q^S_t = K_t + \gamma F_t - \gamma Pb_t \tag{40}$$

$$\pi_t = (1+\gamma)F_t - \gamma Pb_t \tag{41}$$

$$P_t = \alpha_1 \pi_t + \alpha_2 E_t P_{t+1} - \alpha_3 r_t \tag{42}$$

$$D_t = \mu_1 Pn_t - \mu_1 P1_t \tag{43}$$

$$Pn_t = E_{t-1} P_t \tag{44}$$

$$S_t = - \mu_2 P_t + \mu_2 P*_t \tag{45}$$

$$\Delta K_t = D_t - S_t \tag{46}$$

where $E_{t-1}P_{t-j}$ denotes the expectation formed at time t-1 of P_{t+j}. All variables are expressed as natural logarithmss unless otherwise indicated. Equation (39) is identical to (10) and represents the equilibrium condition in the freight market which is that supply must be equal to the completely inelastic, and exogenously determined, demand for freight services. Equation (40) is the log linear version of equation (9). It is the supply of ton-miles function which relates the amount of transportation services offered to the prevailing freight rates and bunker prices. It is also directly proportional to the size of the fleet. The third equation is equation (41) which has been derived from equation (7) by taking logarithms and assuming that fixed costs are zero. It relates the maximum profit that can be obtained by the ship (when running at the optimum speed) to the prevailing freight rates and bunker prices. The fourth equation is equation (42) which is a log linear approximation of (14') with α_1, α_2, α_3 being constants appropriately chosen so as to give a good approximation. It also slightly differs from equation (14') because in the above version π_t has replaced the term $E_t\pi_{t+1}$ in the original. This is simply because here we look at beginning of the period prices whereas in (14') we were looking at end of the period values. The equation has been derived by considering the behaviour of investors in second hand markets. It states that investors, given the expectations of future profits, capital gains and returns on other investments, will bid prices up or down to that level which will bring the expected return on that asset in line with the return on other assets adjusted for risk. In the most general case it was seen that this risk premium might slightly vary with the size of the fleet but here we abstract from such considerations.

Equations (43), (44), (45) are log linear versions of equations (20), (22'') and (23). The first of these equations is the supply of newbuildings which under conditions of perfect competition depends on the price of new ships relative to the cost of shipbuilding. Equation (44) is the relationship between newbuilding and second hand prices while (45) is the relationship between scrapping and second hand values relative to scrap prices. As in the long run analysis we assume that the variables D and S represent deliveries and scrappings as a percentage of the total fleet. This allows as to derive (46) which is the growth rate version of (24).

In order to derive (43), (44) it has been implicitly assumed that it takes a year to deliver a ship. It has also been assumed that shipbuilding, scrapping and second hand markets are open at the beginning of the period only. Thus in the beginning of the period owners decide how many ships should be supplied for scrap on the basis of ship values and scrap prices ruling at that time. These ships are then immediately withdrawn from the market. At the beginning of the period new ships are delivered whose construction began in the beginning of the previous period. These are immediately added to the existing stock of ships. At the same time shipbuilders decide how many ships to begin to construct for delivery in the next period. As already shown, the relevant price for this decision is the newbuilding price which should reflect expectations of future second hand prices.

In order not to overburden the notation we have dropped all those constants representing risk premia, technology and other nuisance effects which do not affect the analysis. Equations (39) - (46) constitute our discrete time model. They have been derived from microeconomic considerations that have been fully described in the previous section. To solve the model we can substitute first equation (39) into (40) which gives

$$q_t = K_t + \gamma F_t - \gamma Pb_t \tag{47}$$

We may solve this for the equilibrium freight rate to obtain (48)

$$F_t = (1/\gamma)(q_t - K_t) + Pb_t \tag{48}$$

implying that equilibrium freight rates are positively related to the level of demand and negatively related to the size of the fleet. Moreover because demand is inelastic an increase in fuel prices is completely passed over to shippers. If this expression is substituted into (41) we obtain the following expression

$$\pi_t = \beta(q_t - K_t) + Pb_t \tag{49}$$

where

$$\beta = (1+\gamma)/\gamma$$

It can be seen that an increase in demand tends to raise the profitability of ships by increasing freight rates while the opposite happens following an expansion in the size of the fleet. An increase in the fuel price will eventually raise the profitability of ships even though its direct effect is to reduce profitability by increasing costs. However because a fuel price increase leads to a proportionate increase in freight rates, the latter more than compensates for the increase in costs. Thus profits increase. This result is not general however but crucially depends on the fact that demand for transportation services is completely inelastic.

Substituting expression (49) into (42) implies the following:

$$P_t = \alpha_1\beta(q_t - K_t) + \alpha_1 Pb_t + \alpha_2 E_t P_{t+1} - \alpha_3 r_t \tag{50}$$

Substituting (43), (45) into (46) implies

$$\Delta K_t = \mu_1 Pn_{t-1} - \mu_1 P1_{t-1} + \mu_2 P_t - \mu_2 P*_t \qquad (51)$$

Use (44) to substitute for Pn_{t-1} in (51) to produce (52)

$$\Delta K_t = \mu_1 E_{t-1} P_t - \mu_1 P1_{t-1} + \mu_2 P_t - \mu_2 P*_t \qquad (52)$$

We are left now with two equations (50) and (52). These involve two unknowns which are P_t and K_t, plus expectations involving these two variables. We can substitute for K_t in order to solve for P_t. To do this we can take first differences of (50):

$$\Delta P_t = \alpha_1 \beta(\Delta q_t - \Delta K_t) + \alpha_1 \Delta Pb_t + \alpha_2 \Delta E_t P_{t+1} - \alpha_3 \Delta r_t \qquad (53)$$

Now use (52) to substitute for ΔK_t in (53) so that we get the following:

$$\Delta P_t = \alpha_1 \beta \Delta q_t - \alpha_1 \beta \mu_1 E_{t-1} P_t - \alpha_1 \beta \mu_2 P_t + \alpha_1 \beta \mu_1 P1_{t-1}$$

$$+ \alpha_1 \beta \mu_2 P*_t + \alpha_1 \Delta Pb_t + \alpha_2 \Delta E_t P_{t+1} - \alpha_3 \Delta r_t$$

$$\Rightarrow \quad (1+\alpha_1 \beta \mu_2) P_t - P_{t-1} + (\alpha_2 + \alpha_1 \beta \mu_1) E_{t-1} P_t - \alpha_2 E_t P_{t+1}$$

$$= \alpha_1 \beta \Delta q_t + \alpha_1 \beta \mu_1 P1_{t-1} + \alpha_1 \beta \mu_2 P*_t + \alpha_1 \Delta Pb_t - \alpha_3 \Delta r_t$$

which can be written as

$$\varphi_1 P_t + \varphi_2 P_{t-1} + \varphi_3 E_{t-1} P_t + \varphi_4 E_t P_{t+1} = z_t \qquad (54)$$

where

$$\varphi_1 = 1+\alpha_1 \beta \mu_2$$

$$\varphi_2 = -1$$

$$\varphi_3 = \alpha_2 + \alpha_1 \beta \mu_1$$

$$\varphi_4 = -\alpha_2$$

and where z_t is defined as

$$z_t = \alpha_1 \beta \Delta q_t + \alpha_1 \beta \mu_1 P1_{t-1} + \alpha_1 \beta \mu_2 P*_t + \alpha_1 \Delta Pb_t - \alpha_3 \Delta r_t$$

and is therefore a weighted average of the growth rate of demand, bunker prices, changes in interest rates and the level of shipbuilding costs and scrap prices. Equation (54) involves only lags, leads and expectations of P_t on the left hand side and z_t on the right. We can anticipate a result that we shall derive later which is that any influence of the exogenous variables on the dynamics of prices arises purely through its effect on z_t and expectations regarding future z_t's, therefore z_t is sufficient to determine the time path of prices. To solve (54) first take expectations at time t-1 across both sides of equation (54).

$$\varphi_1 E_{t-1}P_t + \varphi_2 E_{t-1}P_{t-1} + \varphi_3 E_{t-1}P_t + \varphi_4 E_{t-1}P_{t+1} = E_{t-1}z_t$$

$$\Rightarrow \rho_1 E_{t-1}P_{t-1} + \rho_2 E_{t-1}P_t + \rho_3 E_{t-1}P_{t+1} = E_{t-1}z_t \qquad (55)$$

where

$$\rho_1 = \varphi_2$$

$$\rho_2 = \varphi_1 + \varphi_3$$

$$\rho_3 = \varphi_4$$

Equation (55) is mathematically much simpler that (54) since the latter is a dynamic equation in two endogenous variables, that is *actual* prices P_t and *rational expectations* $E_{t-j}P_{t-j+1}$ of next period prices. On the other hand (55) involves only the expectations of prices and thus the dimension of the problem has been halved following this operation. Equation (55) is a second order difference equation in $E_{t-1}P_{t+k}$. It is convenient to make use of the lag operator L and its inverse; the forward shift operator $F = L^{-1}$. Equation (55) can thus be written as

$$(\rho_1 L^2 + \rho_2 L + \rho_3)E_{t-1}P_{t+1} = E_{t-1}z_t \qquad (56)$$

The characteristic polynomial corresponding to this equation is:

$$\rho_3\lambda^2 + \rho_2\lambda + \rho_1 \tag{57}$$

This second order polynomial has two roots λ_1, λ_2 so that (56) can be written as

$$\rho_3(1-\lambda_1 L)(1-\lambda_2 L)E_{t-1}P_{t+1} = E_{t-1}z_t \tag{58}$$

It can be shown that one of the roots of the polynomial (57) lies within the unit circle $|\lambda_1|<1$ while the other root lies outside $|\lambda_2|>1$. The former is the stable root while the latter is the unstable root. To obtain stable solutions the unstable root must be solved forward. To do this first notice that by multiplying both sides of (58) by $FL = 1$ the equation can be written alternatively as follows

$$\rho_3(1-\lambda_1 L)(1-\lambda_2 L)FLE_{t-1}P_{t+1} = E_{t-1}z_t$$

or

$$\rho_3(1-\lambda_1 L)(F-\lambda_2)E_{t-1}P_t = E_{t-1}z_t$$

or

$$\lambda_2\alpha_2(1-\lambda_1 L)(1-(1/\lambda_2)F)E_{t-1}P_t = E_{t-1}z_t \tag{56}$$

where in the last step we have made use of the fact that $\rho_3=-\alpha_2$. Multiplying both sides of (58') by the inverse of $(1-(1/\lambda_2)F)$ we obtain

$$\lambda_2\alpha_2(1-\lambda_1 L)E_{t-1}P_t = (1-(1/\lambda_2)F)^{-1}E_{t-1}z_t + A\lambda_2^t$$

$$E_{t-1}P_t = \lambda_1 P_{t-1} + (1/(\lambda_2\alpha_2))\sum_{i=0}^{\infty}(1/\lambda_2)^i E_{t-1}z_{t+i} + A\lambda_2^t \tag{59}$$

If $A\neq 0$ then the last term of (59) dominates the solution eventually and prices diverge to minus or plus infinity.

A non zero value for A corresponds to speculative bubble solutions. Assuming that the market moves on the basis of economic fundamentals requires $A=0$ in which case (59) becomes

$$E_{t-1}P_t = \lambda_1 P_{t-1} + (1/(\lambda_2\alpha_2))\sum_{i=0}^{\infty}(1/\lambda_2)^i E_{t-1}z_{t+i} \qquad (59')$$

This states that given P_{t-1}, prices at time t will reflect expectations of future z_t which is a weighted average of the exogenous variables. Using the definition of z_t it can be seen from (59') that second hand prices are positively related to expectations regarding the future level of the growth in demand, the growth rate of bunker prices, the level of shipbuilding costs and scrap prices but negatively related to changes in the return to capital. Let us denote the last term in the above expression as v_{t-1} i.e

$$v_{t-1} = (1/(\lambda_2\alpha_2))\sum_{i=0}^{\infty}(1/\lambda_2)^i E_{t-1}z_{t+i}$$

Thus v_{t-1} is a weighted average of current and expected future demand, bunker prices, alternative returns to capital, shipbuilding costs and scrap prices with positive weight given to all these factors except the return on capital. The term v_t is important for the analysis since given P_{t-1}, v_{t-1} completely determines prices P_t, as (59') indicates. Since v is a weighted average of expected developments in external factors which determine the value of ships, we shall say that "expectations are bullish" if v happens to be high. On the other hand we shall say that "expectations are bearish" if v happens to be low.

Finally in order to solve for P_t use (59') to substitute for $E_{t-1}P_t$ and E_tP_{t+1} in (54). This gives

$$\varphi_1 P_t + \varphi_2 P_{t-1} + \varphi_3(\lambda_1 P_{t-1} + v_{t-1}) + \varphi_4(\lambda_1 P_t + v_t) = z_t$$

$$(\varphi_1+\varphi_4\lambda_1)P_t + (\varphi_2+\varphi_3\lambda_1)P_{t-1} = z_t - \varphi_4 v_t - \varphi_3 v_{t-1}$$

(60)

which is of the form

$$\vartheta_0 P_t - \vartheta_1 P_{t-1} = z_t - \varphi_4 v_t - \varphi_3 v_{t-1} \tag{61}$$

with solution

$$P_t = (1/\vartheta_0)\sum_{i=0}^{\infty} (\vartheta_1/\vartheta_0)^i (z_{t-i} - \varphi_4 v_{t-i} - \varphi_3 v_{t-i-1}) + B\lambda_1^t \tag{62}$$

where $B\lambda_1^t$ is a constant that reflects the initial conditions and which tends to 0 as $t \to \infty$ and can therefore be ignored. Since $\varphi_3 = \alpha_2 + \alpha_1\beta_1\mu_1$ while $\varphi_4 = -\alpha_2$, (62) can be written, after ignoring the last term, as follows

$$P_t = (1/\vartheta_0)\sum_{i=0}^{\infty} (\vartheta_1/\vartheta_0)^i [z_{t-i} + \alpha_2(v_{t-i} - v_{t-i-1}) - \alpha_1\beta\mu_1 v_{t-i-1}] \tag{63}$$

Collecting terms in v_{t-i} this can be written as follows

$$P_t = (1/\vartheta_0)\ [\sum_{i=0}^{\infty} (\vartheta_1/\vartheta_0)^i z_{t-i} + \sum_{i=1}^{\infty} (\vartheta_1/\vartheta_0)^i [(\vartheta_1/\vartheta_0)\alpha_2 - \alpha_2 + \alpha_1\beta\mu_1] v_{t-i} + \alpha_2 v_t \tag{64}$$

We can define ζ as

$$\zeta = -[(\vartheta_1/\vartheta_0)\alpha_2 - \alpha_2 + \alpha_1\beta\mu_1] \qquad \zeta > 0$$

so that (64) can be written as

$$P_t = (1/\vartheta_0)\ [\sum_{i=0}^{\infty} (\vartheta_1/\vartheta_0)^i z_{t-i} - \sum_{i=1}^{\infty} (\vartheta_1/\vartheta_0)^i \zeta v_{t-i} + \alpha_2 v_t] \tag{65}$$

This is the final reduced form for ship prices which relates second hand values to the actual history of the exogenous variables, the past expectations regarding the exogenous variables and the current expectations of these variables, as represented by the first, second and third terms respectively, in the square brackets of (65).

The last term in the square brackets of (65) indicates that prices are positively related to current expectations regarding future growth of demand, bunker prices, shipbuilding costs and scrap prices and negatively related to expected changes in the returns to capital. The more bullish the current expectations the higher the price while bearish expectations imply lower prices.

The middle term of (65) indicates that the more bullish are past expectations, the lower the current price. This is intuitive since bullish expectations in the past contribute positively to past prices which reduce past scrapping and raise past deliveries and thus the current fleet. Moreover bygones are bygones so that past expectations are immaterial for generating current projections which are based on the expectations embodied in the last term v_t, which captures the current mood of the market. The larger fleet generated by previous bullish expectations has negative implications for future profits and thus through rational expectations for current prices.

It can also be seen that past values of z_t have a positive effect on prices. Consider the individual components of z. Higher past growth rates in demand and bunker prices, which are the first two elements of z, imply a higher *level* for current demand and bunker prices. Rational expectations of future levels of these variables are generated by projecting from the current levels, the future expected growth rates embodied in the last term of (65), v_t. The higher the current level the higher the future level implied by these growth rates. Since higher expected demand and bunker prices imply higher expected profits this raises the current level of ship values. A similar argument can be used in order to interpret why higher changes in past returns to capital have a negative impact on prices, given the other elements of (65). The last two components of z_t are the shipbuilding costs and scrap prices. The larger the values of these variables in the past the greater will have been the restraint on the past growth rate of the fleet. This implies a smaller current fleet size which has positive implications about future profits and current prices.

Equation (65) establishes the importance of past and current expectations of exogenous variables for explaining the fluctuations in ship values. Moreover since prices are the primary determinants of scrapping, shipbuilding and thus changes in the fleet, they are also of paramount importance for explaining fluctuations in shipbuilding, demolition, fleet size and consequently freight rates.

3.6 Continuous time model

In this section a continuous time version of the simple model is developed. It will be used to carry simulations which show how ship prices, the fleet, freight rates, profits etc. respond to anticipated or unanticipated changes in external factors such as the level of demand, fuel prices, alternative returns to capital, shipbuilding costs and scrap prices. The external factors operate directly either through the freight market or through the second hand, shipbuilding or scrapping market. However, because of the numerous interactions between these markets, a change in an external factor will in general influence all the remaining markets.

Because our model incorporates rational expectations we can distinguish between anticipated and unanticipated shocks to the external factors. Naturally, as it will be shown, shocks of identical magnitude can lead to significantly different responses depending on whether they have been anticipated or not before their occurence. In this section, the response of the system to unanticipated changes to the external factors will be analysed. Unanticipated shocks are changes that come as a complete surprise to the market and are only realized when they eventually occur. In the following section, the response of the market to anticipated shocks will be considered. Unanticipated shocks are changes to the external factors which the market realizes before they occur. These theoretical simulations enable us to derive some qualitative results regarding the time pattern of the system's response to various shocks.

In the next chapters, the same type of analysis is carried out by means of computer simulations of the estimated econometric model. These will corroborate the qualitative results derived here but in addition they will also give some idea regarding the order of magnitude of the response. Moreover they will also throw some light on the spillover effects among the various ship types which cannot be captured by the single ship type model considered here.

The continuous time model consists of a continuous time version of the same set of equations. These are the following:

$$q^S = q \tag{66}$$

$$q^S = K + \gamma F - \gamma P_b \tag{67}$$

$$\pi = (1+\gamma)F - \gamma P_b \tag{68}$$

$$P = \alpha_1 \pi + \alpha_2 \dot{P} - \alpha_3 r \tag{69}$$

$$\dot{K} = \mu P - \mu_2 P_1 - \mu_3 P_s \tag{70}$$

where $\dot{X}$ denotes the time derivative of X. The first equation is the equilibrium freight market condition. The second one is the supply in the freight market. The third one is the relationship between maximum profits and freight rates and fuel prices. The fourth equation gives the equilibrium price in the second hand market as a function of the instantaneous profitability, the expected capital gain and the alternative returns to capital. The final equation has been derived by combining the newbuilding supply function, the scrapping equation and the identity that describes the evolution of the fleet.

It is assumed here that delivery of new ships is instantaneous thus it is not necessary to distinguish between new and second hand prices which are in this case identical. The constant μ in equation (70) therefore represents a composite positive effect of ship prices on fleet growth. It not only represents the positive effect that higher ship prices have on the fleet growth through stimulating shipbuilding but also the positive effect that arises through the restraint on scrapping.

It is convenient to introduce a new endogenous variable x defined as

$$x = q - K \tag{71}$$

that is x is the logarithm of the ratio between demand and the fleet i.e. of the freight market balance. The introduction of such a variable like x is standard practice in dynamic economic models, were it is more convenient to carry out the analysis in terms of transformations of the endogenous variables which are likely to be constant in the long run. Thus even though the fleet might be continuously growing in line with demand the freight market balance will be stable at the steady state, as the long run analysis has shown. Here, the analysis will be carried out on the x, P space which will be divided into four regions. By combining equations (66) to (70), the equations of motion of P and x shall be derived. These will be used to determine the direction towards which P, x will be moving, when the system happens to be in one of the four particular regions. To do this substitute (66) into (67) which gives

$$q = K + \gamma F - \gamma P_b$$

$$\Rightarrow \; F = (1/\gamma)(q - K) + P_b \tag{72}$$

which, using the definition of x, can be written as

$$F = (1/\gamma)x + P_b \tag{73}$$

This equation simply says that the equilibrium freight rate increases when either the freight market balance or fuel prices increase. Using (72) to substitute for F in (68), gives

$$\pi = \beta x + P_b \tag{74}$$

where

$$\beta = (1+\gamma)/\gamma$$

Substitute the above expression in (69) to get (75) below.

$$P = \alpha_1\beta x + \alpha_1 P_b + \alpha_2\dot{P} - \alpha_3 r \tag{75}$$

By substracting the growth rate of demand $\dot{q}$ from both sides of equation (70) we get the following equation

$$\dot{x} = \dot{q} - \mu P + \mu_1 P_1 + \mu_2 P_s \tag{76}$$

where use has been made of the fact that $\dot{x} = \dot{q} - \dot{K}$. We are left now with the two equations of motion which are (75) and (76). These involve only two endogenous variables x, P and their time derivatives. From (76) it can be seen that at some point in time the freight market balance will be constant ($\dot{x} = 0$) if and only if prices are at a level P^* determined from

$$\dot{q} - \mu P + \mu_1 P_1 + \mu_2 P_s = 0 \tag{77}$$

and this constant level of prices P^* is thus equal to

$$P^* = (1/\mu)\dot{q} + (\mu_1/\mu)P + (\mu_2/\mu)P_s \tag{78}$$

In the x, P space we can draw a vertical line through this point P^* as in figure 3.6. The vertical line through P^* is the $\dot{x}=0$ locus. If at a point in time (77) holds

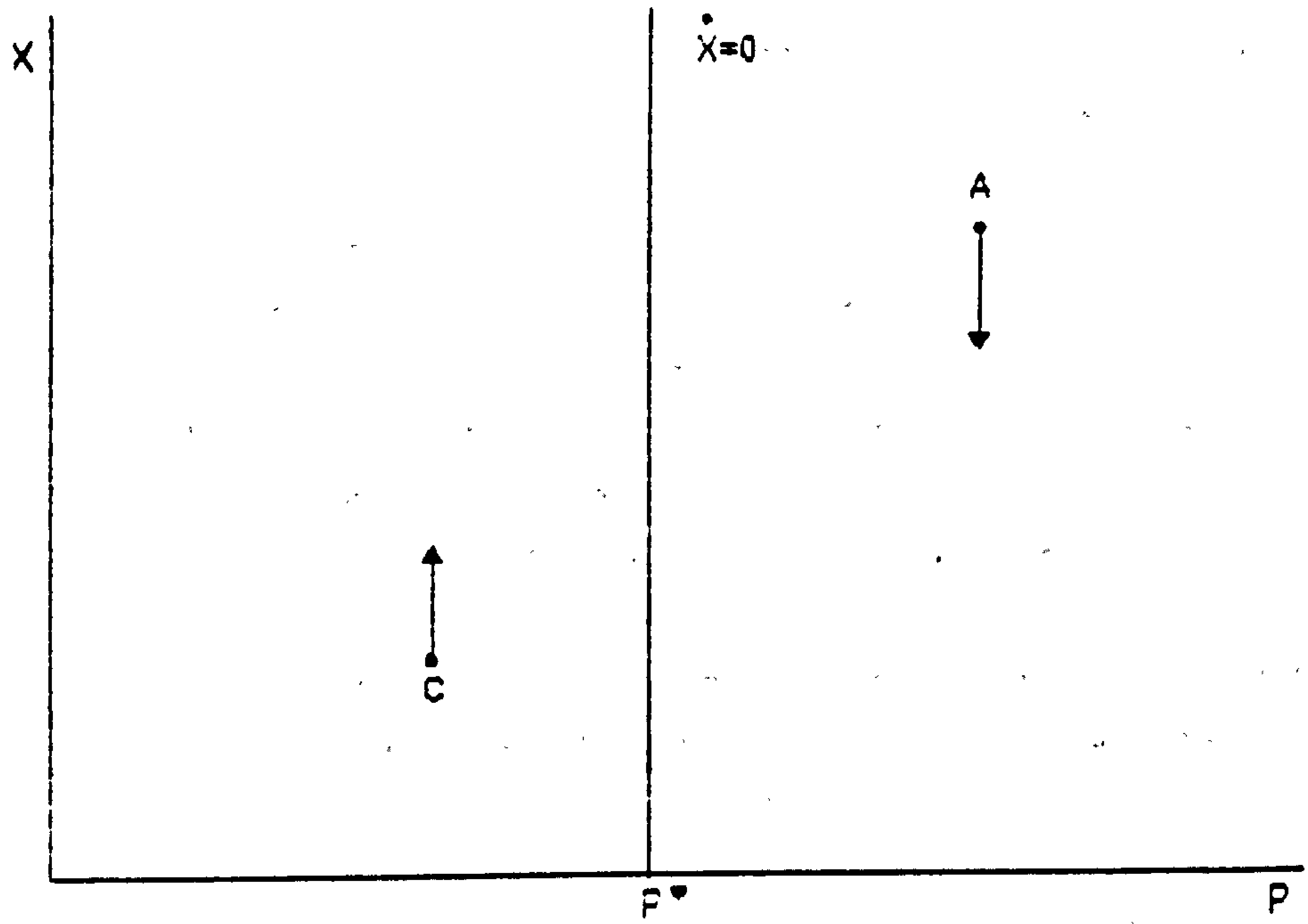

Fig. 3.6 : The $\dot{x}=0$ locus

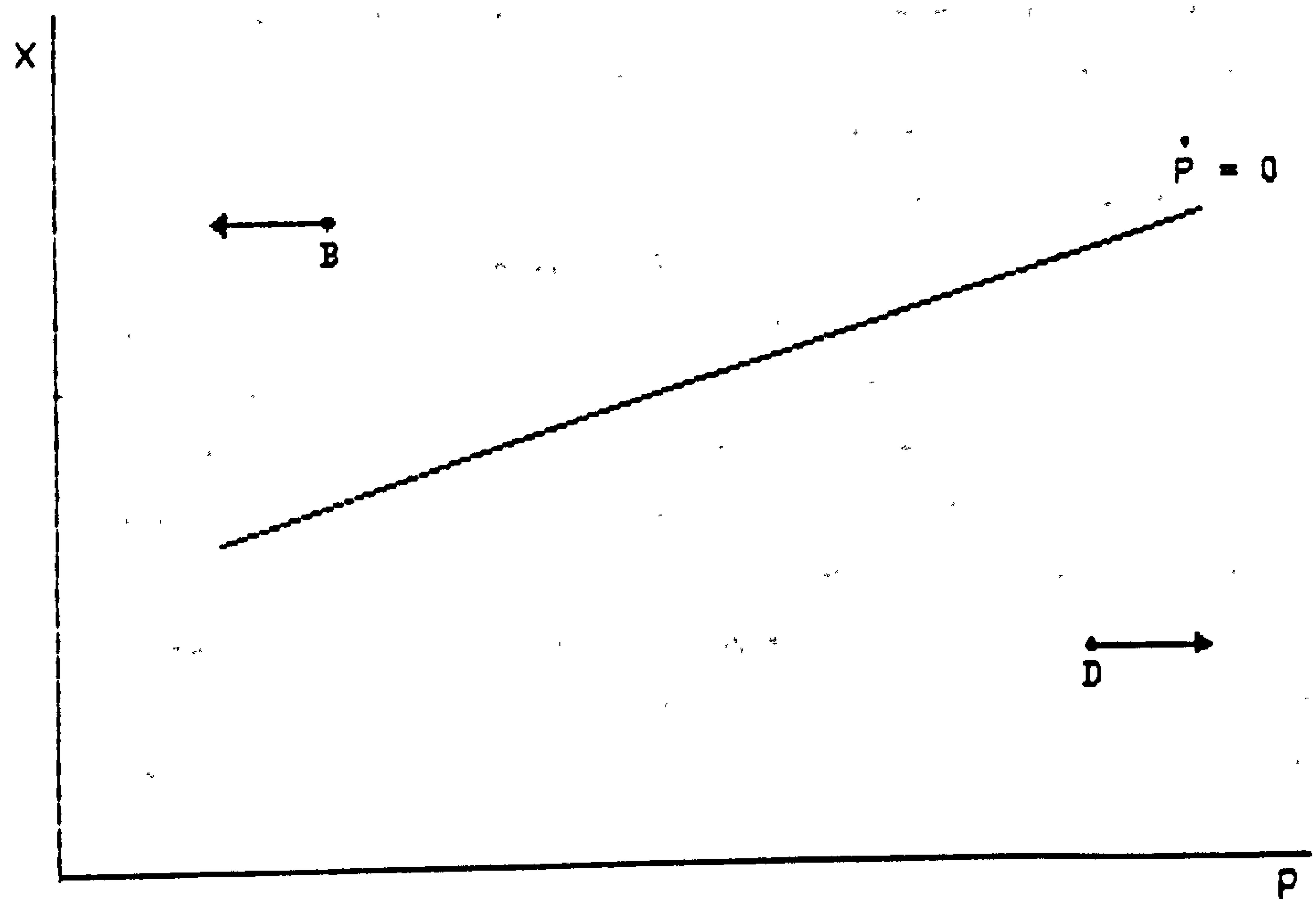

Fig. 3.7 : The $\dot{P}=0$ locus

then $\dot{x}$ must be momentarily equal to zero. Intuitively this is because if prices happen to be at this level, then they stimulate shipbuilding and they restrain scrapping just enough in order to keep the growth rate of the fleet equal to the growth rate of demand. So the freight market balance remains constant.

If on the other hand at some point in time, the system happens to be to the right of this locus i.e $P>P^{*}$, then by simply looking at (76) it can be seen that x must now be falling. Intuitively this is because at a point such as A prices are higher than P^{*}. Given the level of scrap prices and shipbuilding costs there is now more shipbuilding and less scrapping. Thus the growth rate of the fleet will now be higher than that of demand so the freight market balance must be deteriorating i.e. x must be falling. This is indicated by the arrow through point A.

If on the other hand the system happens to be to the left of this locus, i.e. if $P<P^{*}$, then the analogous argument implies that the growth rate of the fleet must be slower than that of demand, so x must be rising as indicated by the arrow through B.

The position of the locus is determined by equation (77) and it can be seen from this that changes to either $\dot{q}$, P_1 or P_s will shift the position of the locus. In particular the locus will shift to the right whenever $\dot{q}$, P_1 or P_s increase. This is natural since higher shipbuilding costs or scrap prices have a negative effect on the growth rate of the fleet and thus will require a higher price P^{*} in order to compensate for this, so as to bring back the growth rate of the fleet in line with that of demand. A higher $\dot{q}$ also requires higher prices in order to maintain the freight market balance.

Similarly, (75) can be used in order to find the locus of points in the x, P space where $\dot{P} = 0$. By looking at (75) this will be true only when

$$P = \alpha_1 \beta x + \alpha_1 P_b - \alpha_3 r \qquad (79)$$

This equation determines a new set of points on the x ,P space which are represented in fig. 3.7 by the upward slopping line. This line represents the $\dot{P}=0$ locus. When x, P are such that system happens to be on that locus, then prices will be momentarily constant.

Intuitively this is because the freight market balance is such that together with the given bunker price it determines a particular profitability for ships. This profitability in relation to the current price P is such that there are no capital gains or losses needed in order to bring the return into line with that of other investments, adjusted for risk. In other words the profitability is such that on its own without any change in values will just give a sufficient return.

From equation (75) it can be seen that if we move to the south east of this locus, say at a point such as D then prices must be rising $(\dot{P} > 0)$. This is because at point D prices are higher while x is lower which means a worse freight market balance. The latter implies a lower profitability. Given that profitability is lower and prices are higher, investors will now be prepared to pay these higher prices only if there are positive capital gains that will raise the return in line with that on other assets. Thus for the system to be at equilibrium at at a point such as D were profits are lower and ships are more expensive, prices must be rising.

On the other hand to the north west of the locus, say at a point such as B, prices are lower while x is higher which which means a better freight market balance. The latter implies higher profits. This lower price therefore can only be an equilibrium price if values are falling in order to keep the return down into line with the return on other assets.

By putting the two loci together as in figure 3.8, it can be seen that they determine four different regions in the x, P space. To the left of the $\dot{x}=0$ locus, x will be rising while to the right it will be falling as already explained. Similarly to the south east of the $\dot{P}=0$ locus P will be rising, while to the north west P will be falling. Through every point in any region two arrows can

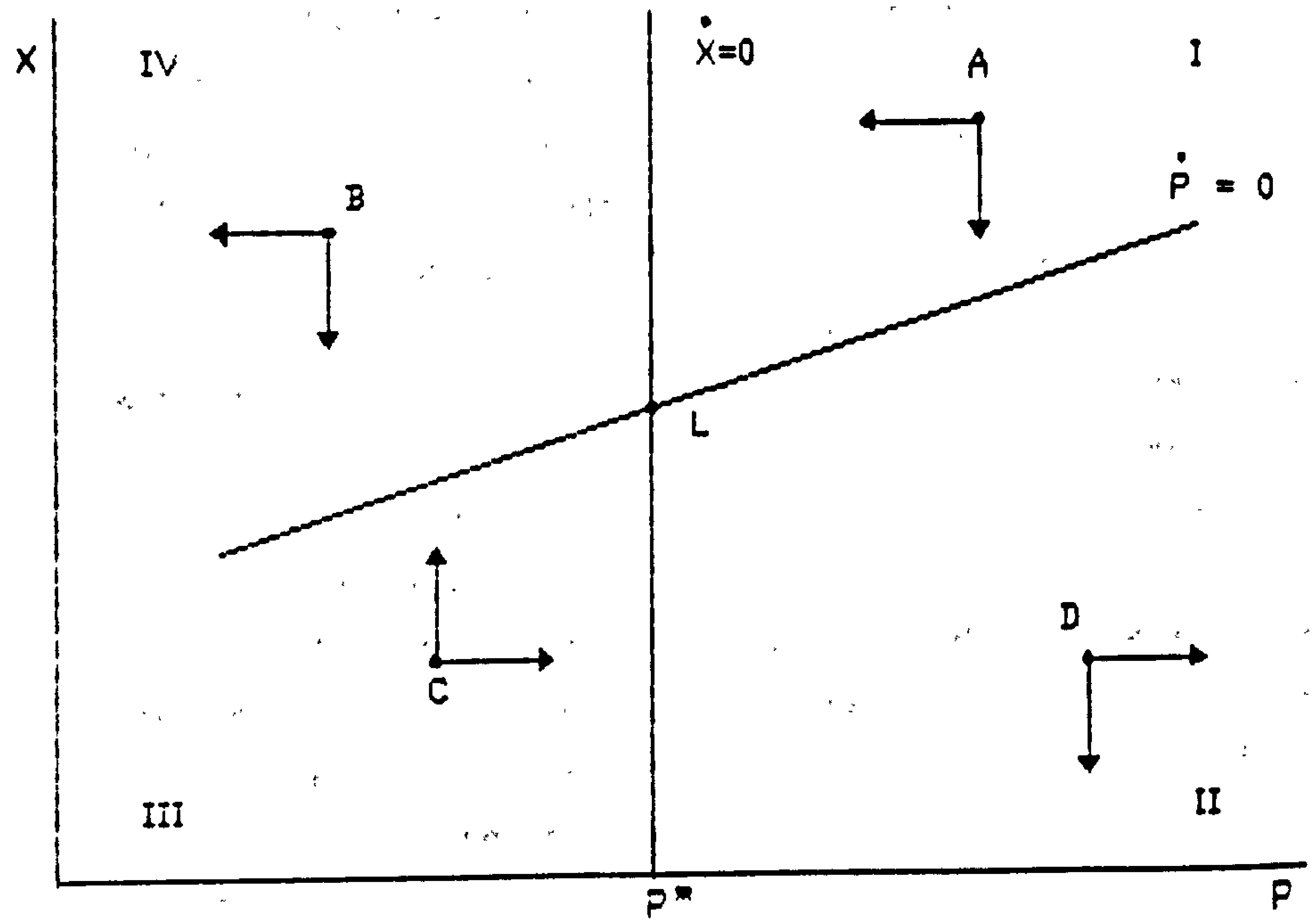

Fig. 3.8 : Phase Dynamics

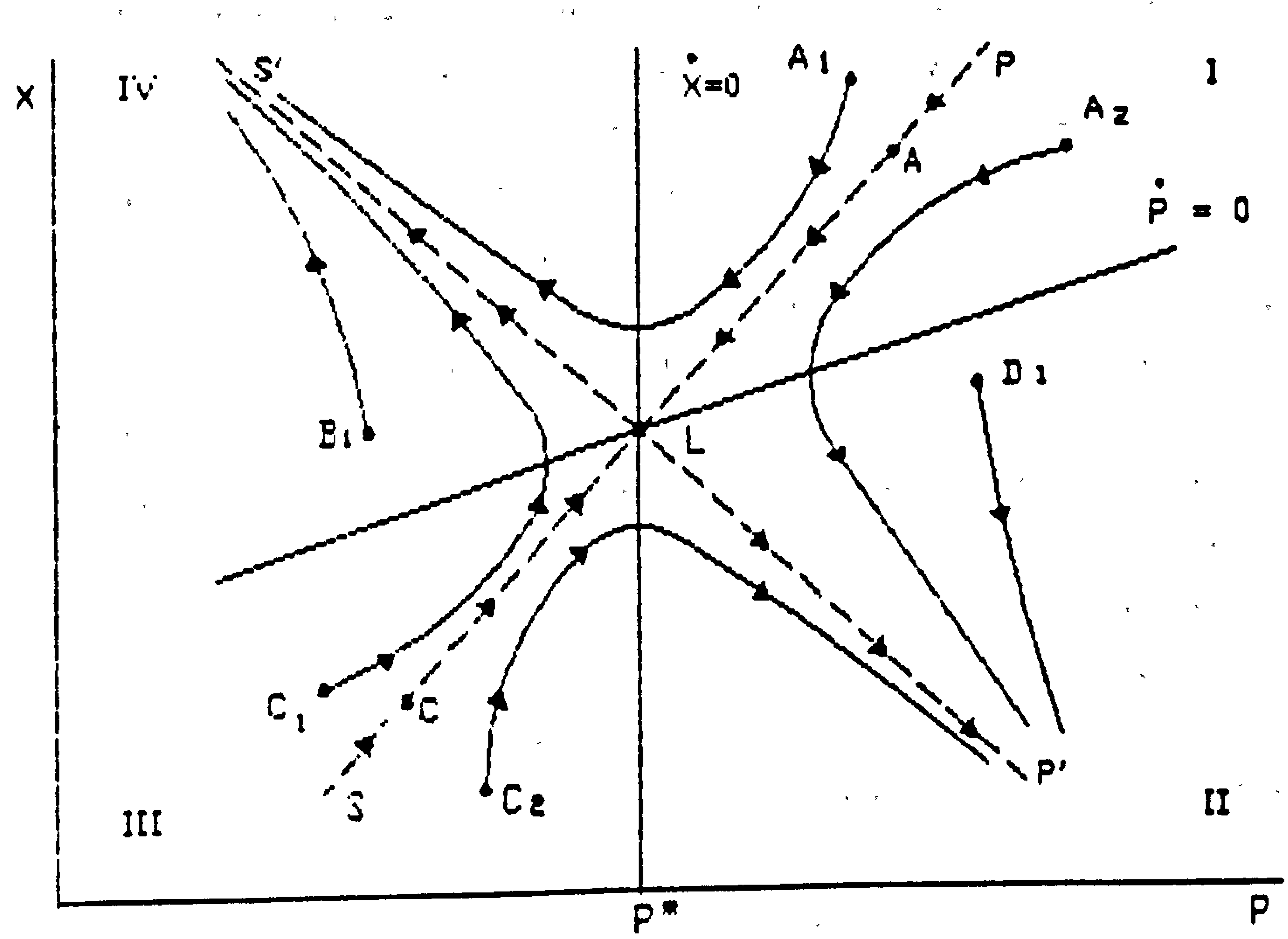

Fig. 3.9 : Solution Paths

be drawn indicating the instantaneous direction of change of x, P when the system happens to be at that point. The direction of the arrows can be determined by simply noting the position of the point in relation to the two loci. Thus, at points above the $\dot{P}$ locus, such as A, B in regions I, IV prices must be falling, while below this locus e.g D,C in II, III prices must be rising. To the left of the $\dot{x} = 0$ locus e.g C,B in III, IV x must be rising while to the right it must be falling. The intersection of the two loci, i.e point L, is the steady state point were the system remains at rest.

By starting from any point and following the direction of the arrows we can trace the evolution of the system over time given its initial position. The various possibilities corresponding to the different initial positions are shown in figure 3.9. Starting from any point of departure, the evolution of the system can be traced by following the arrows. We can first note some qualitative features of the various paths. Thus when the system happens to be on the boundary between regions III and IV the direction of movement should be momentarily vertically upwards. In the boundary between regions I and II the direction of motion should be vertically downwards. Similarly on the boundary between II and III the direction is horizontal to the right while between I and IV it is horizontal to the left.

It can be seen that the system obeys the saddle path property. Thus by taking all solutions that cross either from III into IV or from I into IV and separating them from those that cross from I into II or from III into II we get two curves which converge asymptotically to the steady state point L. This is a saddle path curve represented in figure 3.9 by the upward sloping line SP which passes through L. Similarly be separating all those paths that cross from III into IV from those that cross from III into II and those that cross from I into IV from those that cross from I into II we get another pair of curves that pass through the steady state point L but which are unstable. The latter two curves are represented in figure 3.7 by the downward sloping dotted line through point L.

Should the system happen to be on these unstable paths then it diverges along the direction of the arrows. All other paths are ultimately unstable and they asymptotically move onto one of the two unstable paths through L. Thus when the system is initially at a point such as C_1 or C_2 or B_1 then it eventually diverges and asymptotically approaches from below the unstable saddle path curve. On the other hand if the system is at point A_1 or A_2 or B_1 then it eventually diverges and asymptotically approaches from above the unstable saddle path curve. Similar unstable paths can be derived by starting from any other point in any region. Only if the initial x, P point happens to be on the saddle path curve SP which passes through point L (e.g points A, C), will the system converge to the long run equilibrium.

This might suggest that the system is unstable, that it is in general it will diverge. One might say that only if by chance we happen to be on the saddle path curve initially, will the system be stable. There is an alternative interpretation however which makes the system globally stable. All the divergent solutions correspond to speculative bubble paths. The bubble free solution is however unique and is represented by the saddle path route. At a particular point in time, x is given by the exogenous level of demand and the historically determined size of the fleet. The price of ships however is a free variable which can instantaneously jump to any level the market determines.

Thus in Fig. 3.10 the initial x, P point will have to lie some where on the horizontal line through this given value for x, which is denoted by x^I in figure 3.10 below. On the other hand the ship price P is free to move to any level. If the system follows the 'bubble' free dynamics then it has to move to the level that will set the system on the saddle path. In terms of figure 3.10 this implies that the initial equilibrium is at point I which is determined by the intersection of the horizontal line through the historically given level of x, that is x^I, and the saddle path line.

The system moves over time in the direction of the arrows from the initial point, that is it converges to the long run equilibrium *L*. Starting from any other point on the horizontal curve through x^I, the system will eventually diverge. The assumption that prices can jump instantaneously in order to set the system on the convergent saddle path is not an arbitrary one. All the unstable solutions are 'bubble' paths. They are analogous to the unstable solutions of equation (14) which are given by (17). These appear when we set the undetermined coefficient *A* to some value other than *0*. On the other hand the saddle path solution is the solution that assumes that there are no 'bubble' elements in the development of ship prices. In terms of equation (17) it corresponds to the case were $A=0$. It was seen in section 3.4 when the possible solutions of equation (14) were studied, that the 'no bubble' solution is the solution that expresses prices purely as a function of the economic fundamentals only. Unstable solutions differ from the the stable one by an arbitrary time dependent constant $A(1+r)^t$ which has no economic interpretation. Moreover this term if nonzero will eventually explode to minus or plus infinity and thus it will dominate the price path. The empirical evidence clearly shows that ship prices do not diverge. This implies that either bubbles do not appear at all or if they do they eventually burst. The latter implies economic loss and this provides an economic rationale for assuming that the system follows the bubble free saddle path.

3.7 Unanticipated Shocks

In this section, the phase diagram is used in order to consider how the system responds to various shocks. First, an arbitrary set of assumptions regarding the initial conditions (such as the size of the fleet) and the future path of the external factors is made. These generate a particular equilibrium base run path which the system would follow in response to the assumed base run external influences. Then a change in the assumed path of one of the exogenous factors or one of the initial conditions is introduced and the new path that the system would follow in response to this change, is calculated. The two paths are then compared and the simulation results are summarized by calculating the deviation of the new path from the base run path.

Since the base run assumptions are arbitrary we might as well chose the simplest possible ones. Thus it will be assumed that all external factors such as the growth rate of demand, fuel prices, alternative returns to capital, prices of shipbuilding inputs and scrap prices are constant forever. This means that on the phase diagram the positions of the two loci remain constant and thus there is a unique long run equilibrium at point L. It will also be assumed that the initial value of x is the one which corresponds to point L. Thus in the base run the system is at point L at time zero and remains at this point forever.

We can now calculate the path that the system would follow should there be a completely unexpected change in one of the external factors. To carry out the analysis, it is sufficient to look at the two loci and how their position will change following an external shock. By keeping the system on the 'no bubble' new saddle path the new solution can be derived.

3.7.1 Permanent unanticipated increase in the level of demand

Let it be assumed that while the system is at rest at point L, there is suddenly, at time 0, an unexpected permanent increase in the level of demand. To follow the market movements we can use the phase diagram of fig 3.10 and also the diagrams of fig 3.11 which are a translation of the phase diagram's system movements on a time axis. In terms of the phase diagram the change in the level of demand does not affect the position of the two loci but

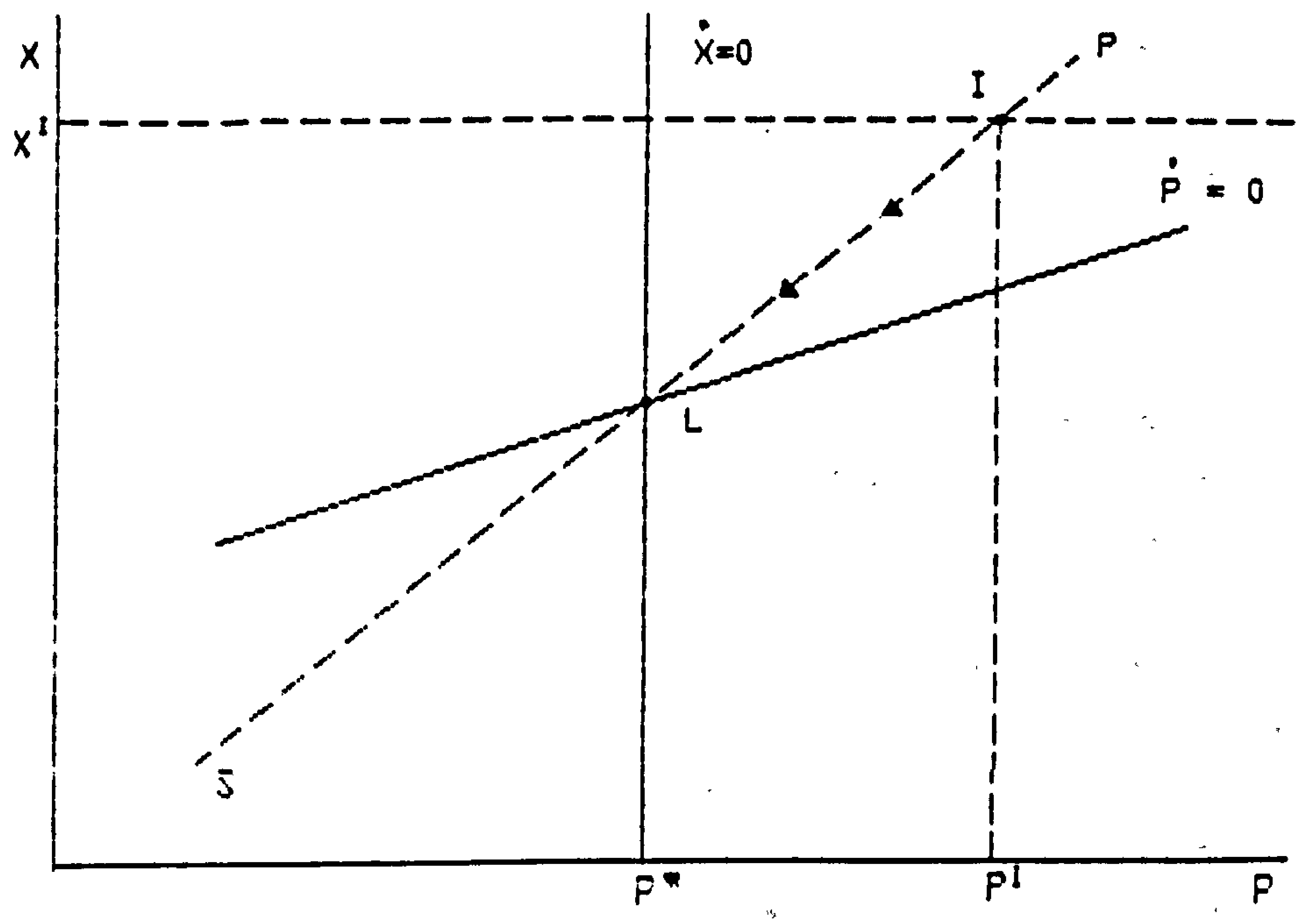

Fig. 3.10 : Unanticipated increase in the level of demand

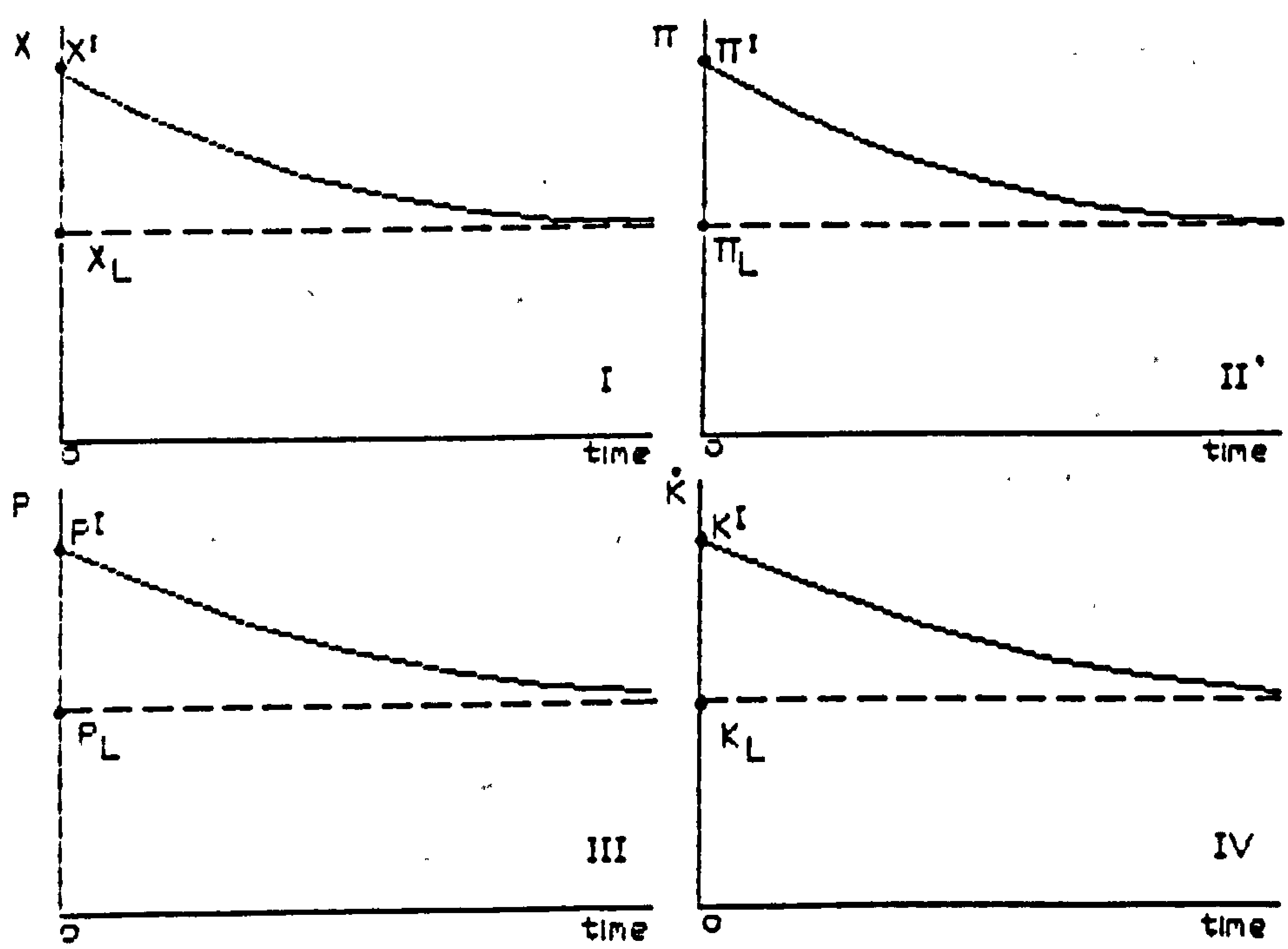

Fig. 3.11 : System's response to demand shock

it will instantaneously change the initial value of x, that is the freight market balance will immediately improve. Thus x increases instantaneously to some level say x^I in figure 3.10. The new long run equilibrium of the system is again the same as in the base run, point L, since the position of the two loci is unchanged.

The initial equilibrium however is given now by the intersection of the horizontal line through x^I and the saddle path curve SP through L. The intersection occurs at point I. Thus prices jump initially from the point represented by L to the point represented by I.

The evolution of the system over time can be traced by moving along the saddle path in the direction of the arrows. The system will traverse along the segment IL.

Fig. 3.11 shows how the freight market balance, profits, ship prices and the fleet growth rate will move over time as the system will be traversing along IL in fig. 3.10. Fig 3.11 shows four diagrams. Diagram I depicts the time path of the freight market balance (x), diagram II shows the path of profits (π), diagram III shows the evolution of ship prices (P) and finally diagram IV depicts the time path of the fleet growth rate ($\dot{K}$). The horizontal dotted line on each diagram shows the time path of the variable under the base run scenario were the system is at rest at point L. Thus in the base run freight market balance is constant at a level x_L, profits at π_L, prices at P_L and fleet growth rate at K_L. The solid line in each diagram represents the new path that the variable would follow in the case of the unexpected shock. Alternatively and more generally it can be thought off as representing the deviation of the system's shocked path from an arbitrary base run path.

At time 0, when the shock occurs, the system moves to point I in fig. 3.10. At that point both the freight market balance and prices are higher. In terms of fig. 3.11 this is indicated by the fact that in diagram I, x moves instantaneously from the base run level x_L to the new higher level x_I. At time 0, prices also jump from P_L to P_I as shown in fig. 3.11 (IV). Because of the freight market tightening, profits jump from the base run level

π_L to a higher level π_I as fig 3.11 (II) indicates. Because of the higher prices scrapping decreases while shipbuilding expands. Thus, at time 0 and as fig. 3.11 (IV) shows, the growth rate of the fleet instantaneously increases from K_L to K_I.

Because of the higher prices the growth rate of the fleet rises above the base run level. The higher prices imply that there is more shipbuilding and and less scrapping which causes the fleet to grow at a faster rate than demand. Thus the freight market balance, although at a high level initially, begins to fall gradually towards the base run level. There will be sometime before the market balance and consequently rates and profits, approach the base run level, as the fleet can only respond with a finite speed. In the meantime profits will remain above the base run level even though they will be dropping continuously towards π_L as the increase in the fleet begins to eat away the initial improvement in market balance. This temporary freight market boom, makes room for the initial speculative increases in ship values. The initial speculative jump caused by the 'news' regarding the higher level of demand, is limited by the fact that the higher values will raise the growth rate of the fleet. This will tend to restrain future rates and profits. Equilibrium is achieved at a price level where the future expected profits that are likely to be generated by the external shock and the response of the system are just sufficient to earn a return on the initial price.

The system exhibits the overshooting property. Market balance, profits, prices and fleet growth rate overshoot the long run level at which they eventually settle. In the short term the fleet is fixed. This helps to create a temporary freight market shortage and market balance improves causing an increase in rates and profits. Inspite of the expected return to normality, the increase in profits justifies a speculative jump in values. Subsequently the fleet responds and overtime the market moves towards the base run level. At time 0 the market anticipates the oncoming recessionary phase and thus the increase in prices is less than proportionate to the increase in profits. This raises the yield on ships and this is needed in order to compensate for the anticipated future capital losses caused by the tendency to return to normality.

The above simulation results as well as the ones discussed below, are not meant to be entirely presentative of what actually happens in practice. This reflects the fact that a number of simplifying assumptions have been made in order to allow quick derivation of the results without at the same time significantly distorting the real world picture. For example it has been assumed that shipbuilding supply responds immediately to current prices. In reality supply of newbuildings is predetermined in the short run by decisions taken in the past and only the future supply can respond to unexpected changes in prices. If this construction lag had been taken into account, then the timing and magnitude of the system's fluctuations would have differed somewhat. Inspite of that, the simulations presented do capture the broad features that a more realistic model would have generated. This neglect of some real world features is justified on the grounds that their incorporation into the theoretical model would have considerably complicated the theoretical analysis without materially altering the results. At the same time simulations of more realistic hypothetical models could conceal the importance and the workings of the fundamental forces that we have already taken into account, by bringing into the picture less essential details. In any case, this problem of some lack of realism is considerably remedied in the following chapters were computer simulations of the more realistic econometric models are presented.

3.7.2 Permanent unanticipated increase in growth rate of demand

The effects of an unanticipated increase in the

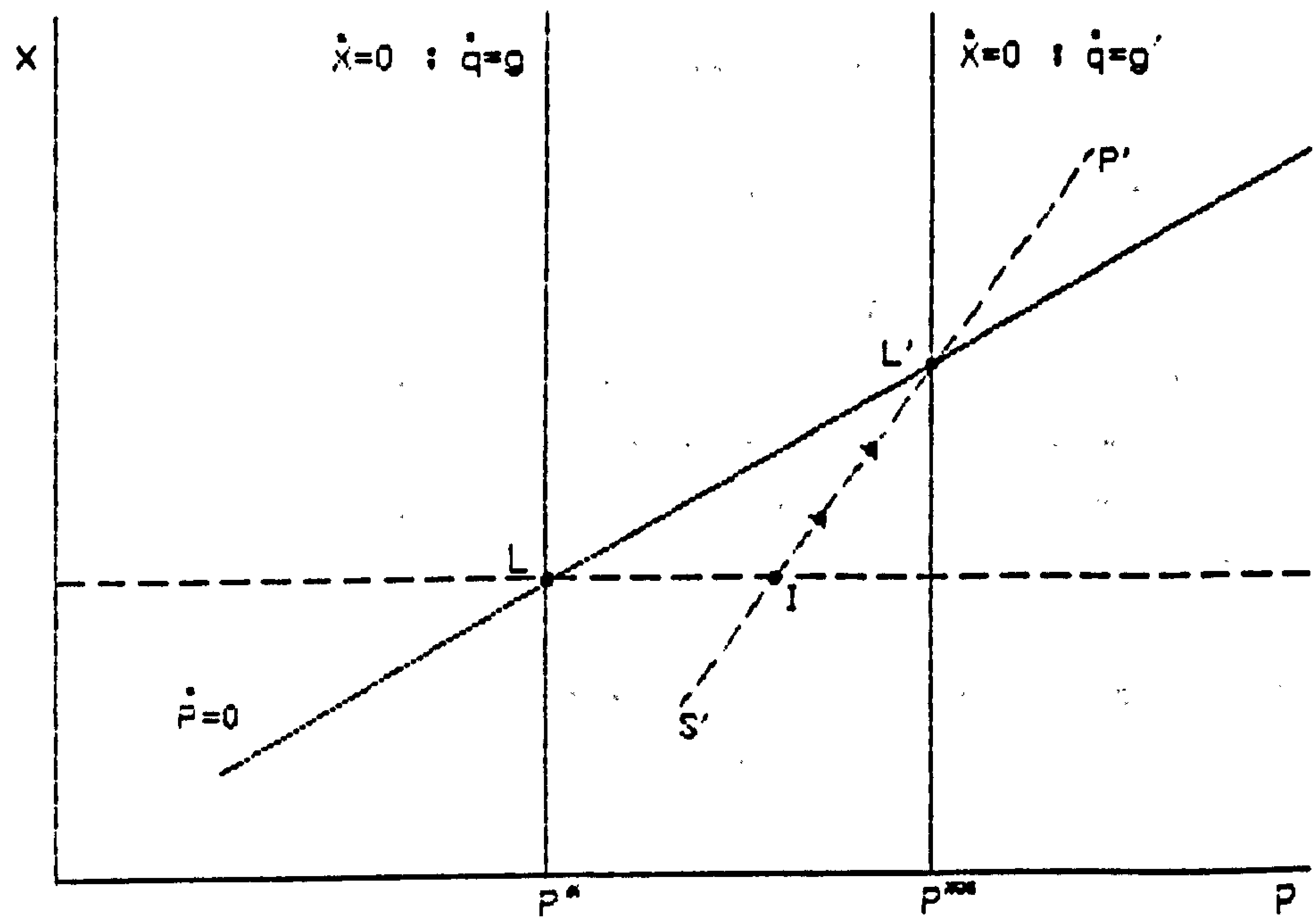

Fig. 3.12 : Unanticipated increase in demand growth rate

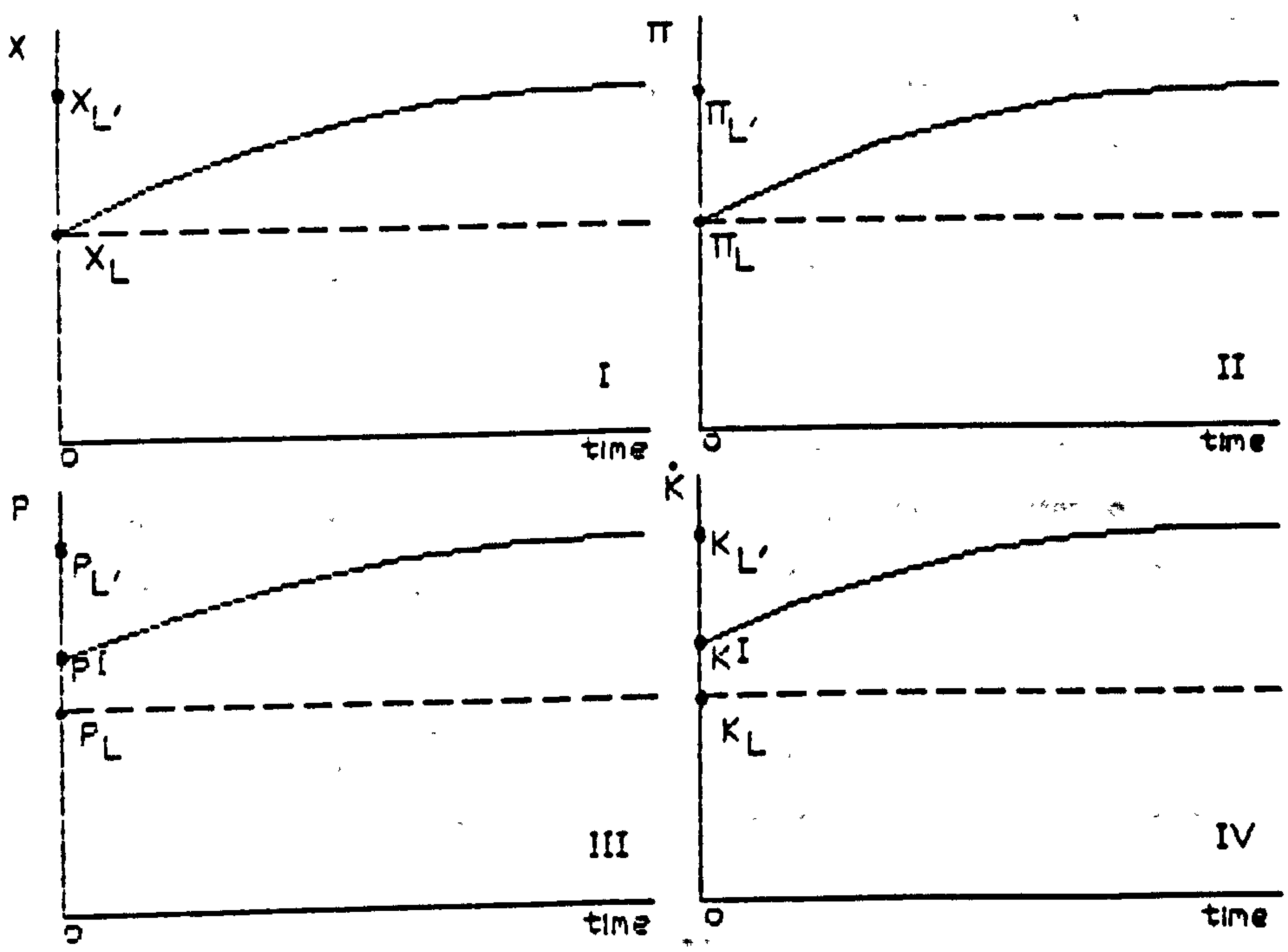

Fig. 3.13 : System's response to demand growth shock

growth rate of demand from a level g to a higher level g', are shown of fig. 3.12 and fig. 3.13. In terms of the two loci the shock will have the effect of shifting the $\dot{x}=0$ locus to the right while the position of the $\dot{P}=0$ locus is not affected. Mathematically this can be seen by looking at equations (77), (79) that determine the positions of the two loci. Intuitively the $\dot{x}=0$ locus shifts because now that the growth rate of demand is higher, a higher level of ship prices is needed in order to stimulate shipbuilding and suppress scrapping so as to raise the growth rate of the fleet in line with that of demand.

Fig. 3.12 shows the position of the loci before and after the shock. The vertical line $\dot{x}=0:\dot{q}=g$ through the point P^{*} denotes the position of the $\dot{x}=0$ locus before the shock when demand growth is at the low level g. Following the increase in demand to g', this locus shifts to the right, to a new position indicated by the vertical line $\dot{x}=0:\dot{q}=g'$ through the point P^{**}. The $\dot{P}=0$ locus does not shift. Following the shift in the $\dot{x}=0$ locus there is a new long run equilibrium established at point L' to which the market will eventually move to.

There is also a new saddle path curve $S'P'$ through the point L'. Initially the market moves to point I which is determined by the intersection of the horizontal line through the fixed and historically determined freight market balance and the new saddle path curve $S'P'$. Over time the market will move from point I to point L' as the arrows indicate.

Fig. 3.13 translates these phase diagram movements on a time scale. It can be seen that freight market balance is initially unchanged and so are profits. They gradually begin to increase however and in the long run they settle to a level $x_{L'}$ and $\pi_{L'}$ respectively. Prices and the growth rate of the fleet immediately jump to a level P^{I} and K^{I} and begin to climb towards the long run level $P_{L'}$ and $K_{L'}$ respectively.

The initial level of demand is not changed by the shock. Thus freight market balance and profits are initially unchanged. However the rate of change of demand

and thus its future level has increased. These news lead to the speculative jump in values from P_L to P^I. This causes an expansion in the growth rate of the fleet, through increased supply of newbuildings and a reduction in scrapping. Informed speculation implies that the jump in prices will be sufficiently restrained to a level P^I so as to hold down the increase in the growth rate of the fleet to a level K^I lower than g'. Only then will the fleet lag behind demand so as to allow future profits to increase and thus repay the higher initial price P^I. Higher/lower prices than P^I are rejected by the market since they imply higher/lower fleet growth rate which in turn through its effect on profits will imply an insufficient/excess return to be earned. As time passes by, investors are prepared to pay higher prices for ships since they are faced with a higher discounted profit profile. The progressive increase in prices leads to further increases in the growth rate of the fleet which tends to move closer to g' and thus there is a decelaration in the rate of increase of market balance and profits. Eventually profits and prices increase to an extent that fleet growth catches up with that of demand (g') and thus the market settles to a new long run equilibrium. In the mean time the fleet growth has lagged behind that of demand which implies permanent improvements in market balance. These are supported by the long run fundamentals of the market. The higher long run balance is needed to raise profits and prices permanently so as to bring up the fleet growth in line with that of demand.

3.7.3 Permanent unanticipated increase in bunker prices

A permanent increase in the level of P_b from a level say a to a higher level a' will shift the $\dot{P}=0$ locus to the right while the position of the $\dot{x}=0$ locus will not be affected. Mathematically this can be seen by looking at equations (77), (79) that determine the positions of the two loci. Intuitively the locus $\dot{P}=0$ shifts because now for a given value of x the implied profitability is higher. Thus a smaller capital gain is needed in order to maintain the return at the equilibrium level. The impact effects of an increase in the fuel price on freight rates and profits can be derived by considering equations (73) and (74). These suggest that for a given freight market balance an increase in the price of fuel will increase equilibrium freight rates and profits by a proportionately identical amount. This effect of a fuel increase on profitability crucially depends on the assumption of a completely inelastic demand that we have made. Should the demand be elastic the impact effects of fuel price increases on profits could very well be negative, if the elasticity of demand was sufficiently high. However, here where demand is assumed to be completely inelastic, most of the increase in costs is passed over to shippers thus rates and profits increase.

The new positions of the two loci before and after the shock are shown in fig. 3.14. The shock shifts the $\dot{P}=0$ locus to the right. The $\dot{P}=0{:}Pb=a$ line through point L indicates the position of this locus before the shock. After the shock, it moves to the right to a new position indicated by the $\dot{P}-0{:}Pb=a'$ line through point L'. There is a new long run equilibrium at point L' and a new saddle path $S'P'$ through this new steady state.

Initially the market moves to point I where prices are higher but freight market balance is unchanged at the historically determined level. Over time the market begins to move from point I to the new long run equilibrium point L' as indicated by the arrows.

Fig. 3.15 shows the fluctuations of x, π, P, $\dot{K}$ caused by the increase in the bunker prices. The initial freight market balance is not affected by the shock. Inspite of that profits immediately increase from π_L to π^I as the increase in fuel costs creates an artificial freight market shortage through the incentive to slowsteam. The fleet cannot respond immediately and the freight market boom is expected to last for some time. This causes a speculative increase in values from P_L to P^I. This in turn leads to an expansion in the growth rate of the

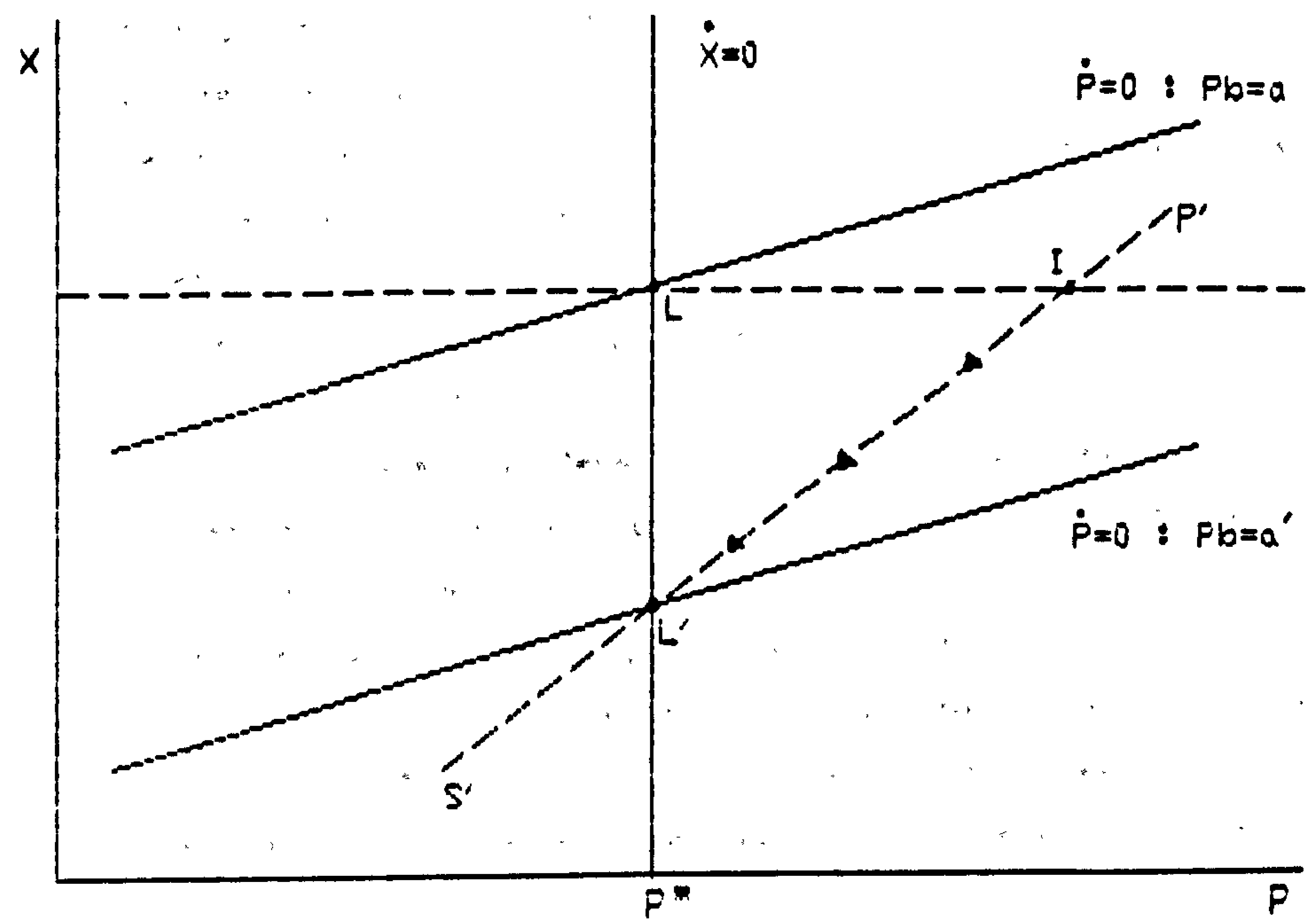

Fig. 3.14 : Unanticipated increase in bunker prices

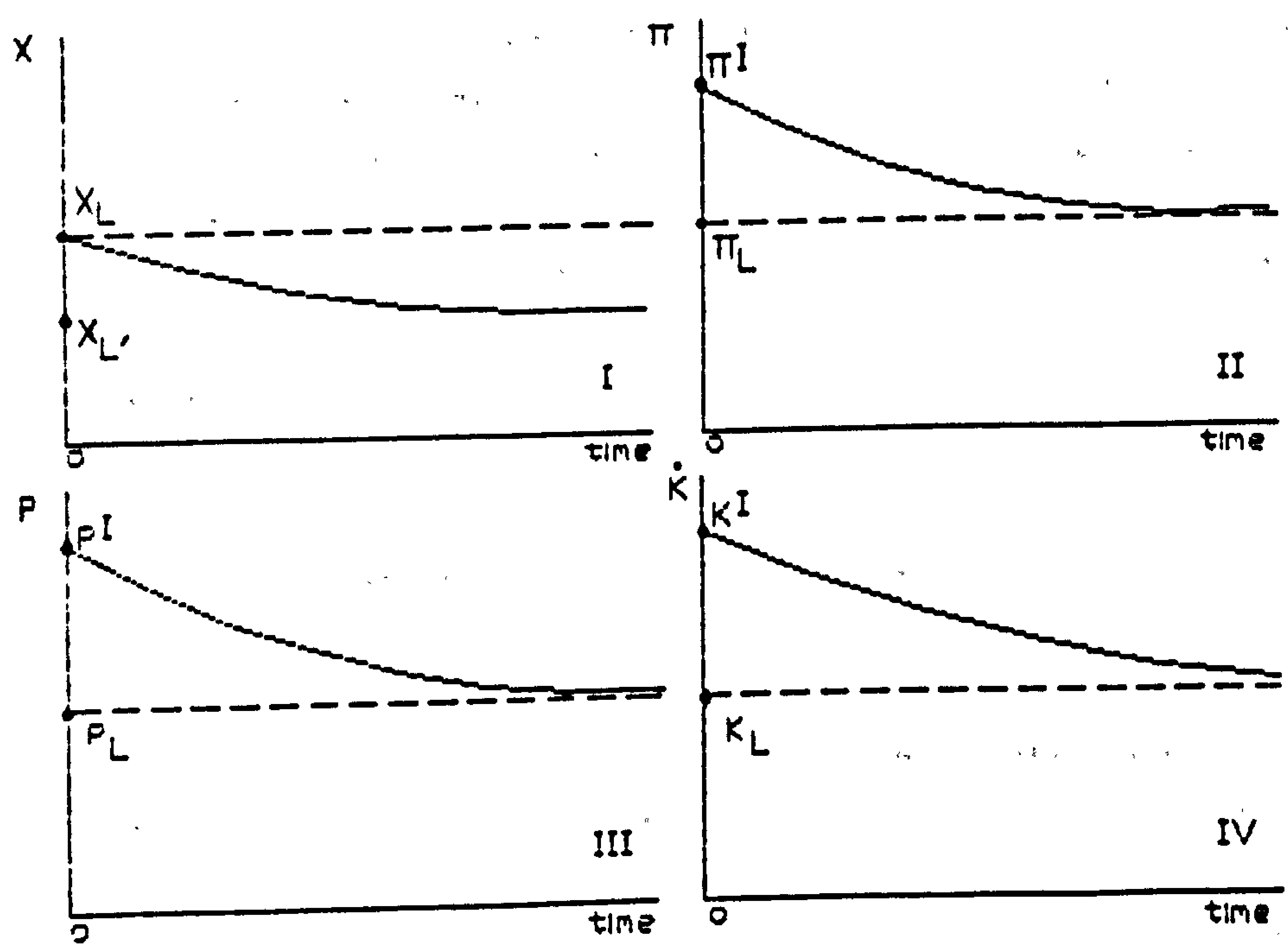

Fig. 3.15 : System's response to bunker price shock

fleet from K_L to K^I as scrapping decreases and shipbuilding expands. The size of the speculative jump in values is limited by the fact that it will tend to restrain future profitability through its positive effect on the fleet. The expansion in the growth rate of the fleet implies that over time the freight market balance begins to deteriorate and thus profits begin to fall from their high initial level. Profits however still remain above the base run level as the positive effect of the bunker price increase, outweighs the negative effects of the deteriorating market balance. Overtime values fall as investors are progressively faced with a lower profit profile. Thus prices return towards the base run level and so does the fleet growth rate. In the mean time the fleet has grown faster than demand thus eventually market balance falls to a level x_L.

This drop in market balance exactly outweighs the positive effect of higher bunker prices on profits. Profits and prices and consequently fleet growth return to the base run level. The freight market balance , however, drops permanently and this reflects permanent slowsteaming. The shipbuilding boom raises the size of the fleet which lowers x. The given level of demand is now satisfied by more ships running at slower speed.

This indicates the efficiency of free shipping markets from a welfare point of view whereby the system reacts to the shock by building more ships the construction costs of which are unchanged and by economising on expensive fuel.

3.7.4 Permanent unanticipated increase in shipbuilding costs (or scrap prices)

This section considers what happens in the case where there is a permanent unanticipated increase in the price of shipbuilding inputs. The qualitative effects of such a shock are identical to those arising from an unanticipated increase in the price of scrap which here is treated as exogenous. In what follows it shall therefore be assumed that there has been an unanticipated permanent increase in the level of shipbuilding costs, having in mind that exactly the same results are obtained when an increase in the price of scrap occurs.

Both an increase in the price of the shipbuilding input or in the price of scrap have the effect of shifting the $\dot{x}=0$ locus to the right. This is because an increase in shipbuilding costs will tend to reduce the supply of new ships at a given level of ship prices and it will thus require higher prices in order to keep the growth rate of the fleet in line with that of demand. Thus the $\dot{x}=0$ locus moves to the right. On the other the position of the $\dot{P}=0$ locus is not affected.

Fig. 3.16 shows the position of the loci before and after the increase in shipbuilding costs from a level say a to a higher level a'. The position of the $\dot{x}=0$ locus prior to the shock, is represented by the vertical $\dot{x}=0:P_1=a$ line through P^*. The position of this locus after the shock is indicated by the vertical line $\dot{x}=0:P_1=a'$ through point P^{**}. The position of the $\dot{P}=0$ locus is not affected. There is a shift in the long run equilibrium from point L to point L'. The initial equilibrium is determined by the intersection of the horizontal through point L and the new saddle path $S'P'$. This is point I in fig. 3.16. From time 0 onwards the system moves in the direction of the arrows from point I to the new long run equilibrium point L'.

Fig. 3.17 shows the fluctuations in the system's variables following the shock. There is no impact effect on the freight market balance or on the profitability as the level of demand, bunker prices and fleet are initially unchanged. However, the news regarding the permanent increase in the level of shipbuilding costs generate speculation in the second hand markets which causes the ship price to jump from P_L to P^I in anticipation of the restraining effects of the shock on the fleet growth rate. The increase in values would tend to expand the supply of new ships and thus partly cancel the restraining effect of the increase in costs. This is indeed true but the speculative jump in values is

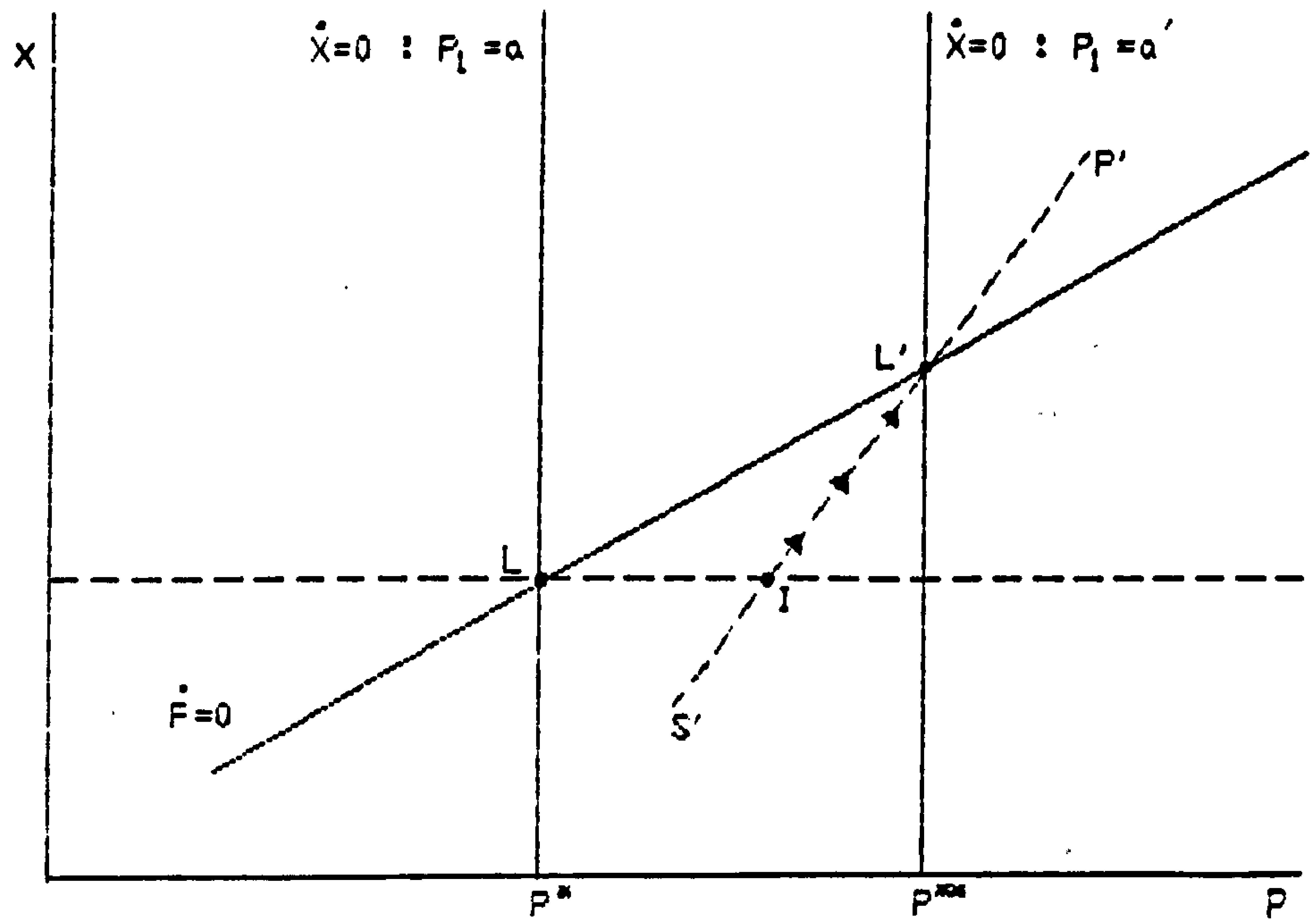

Fig. 3.16 : Unanticipated increase in shipbuilding costs

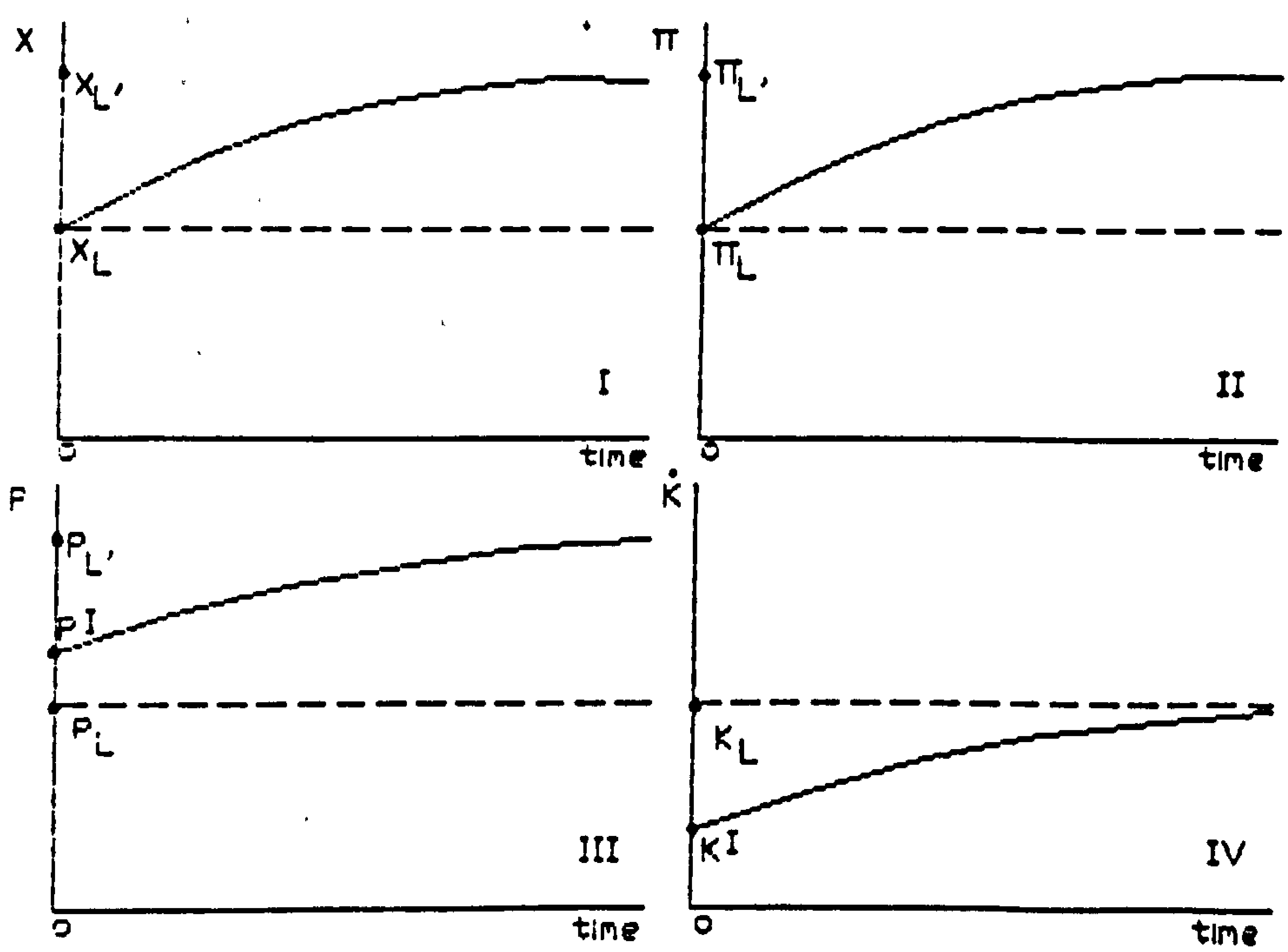

Fig. 3.17 : System's response to shipbuilding cost shock

proportionately smaller than the increase in costs. Thus prices relative to shipbuilding costs do drop initially and this causes the growth rate of the fleet to fall to K^I. This result does not depend on any assumptions we have made regarding various elasticities.

From time 0 onwards, the freight market balance and thus profits begin to improve as the fleet growth drops. As the fleet growth continuously lags behind demand, freight market balance improves further and thus profits also continue to increase. Investors begin to pay progressively higher prices for ships as with the passing of time a higher profit profile lies ahead of them. This is thanks to the fact that the drops in the fleet size are accumulated over time. The higher prices however lead to further cancelling of the restraining effects of the higher costs on the newbuilding supply. Thus the fleet growth picks up and tends to return towards the base run level. Eventually profits and prices rise by an amount which completely cancels the restraining effects of the shock on the fleet. Thus the market settles to a new long run equilibrium where the fleet growth rate returns to the base run level. Thus eventually the fleet moves in line with demand. In the meantime the accumulated cutbacks in fleet growth has led to a permanent improvement in freight market balance, profits and prices. These are necessary in order to raise the long run growth rate of the fleet to equal that of demand. There is also permanent reduction in slow steaming as the higher x implies higher freight rates and thus speeds.

Again the efficiency of the free market mechanism is indicated by these movements. The system reacts to the shock, by cutting back the more costly production of ships and satisfying the given demand by higher utilization of the remaining fleet through higher speeds and higher consumption of fuel the price of which has not changed.

It can be seen from fig. 3.17 that this shock leads to prices undershooting their new long run equilibrium level whereas the fleet growth overshoots.

3.7.5 *Permanent unanticipated increase in alternative returns to capital (r)*

An increase in r from a level say a to a higher level a' will shift the $\dot{P}=0$ locus to the left leaving the $\dot{x}=0$ locus unaffected. This is because at a given x,P point stronger capital gains will now be needed in order to raise the return on ships closer to the new higher value of r. Fig. 3.18 the position of the various loci before and after the shock. The position of the $\dot{P}=0$ locus prior to the shock is indicated by the upward sloping line $\dot{P}=0{:}r=a$ through L. There is a new long run equilibrium at point L'. There is also a new saddle path curve $S'P'$ through this point.

Following the shock the initial equilibrium is determined by the intersection of the horizontal through L and the new saddle path curve. This is point I of fig. 3.18. From then on the system begins to move in the direction of the arrows towards point L'.

Fig. 3.19 shows the system's fluctuations against time following the change in r. There is no impact effect on the freight market balance and profits as initially the level of demand, the fleet and bunker prices are unchanged. However in the second hand markets there is a tendency for investors to switch to other assets in order to earn the higher return. At equilibrium, ships must be willingly held in investors' portfolios and this requires an immediate drop in values from P_L to P^I. This helps to raise the return on ships. The drop in values leads to increased scrapping and reduced supply of newbuildings thus the fleet growth rate immediately drops down to K^I. This in turns helps to raise future profits and this restrains the initial speculative drop in values.

Because of the drop in the fleet growth rate the freight market balance begins to improve and thus so do profits. This in turn helps to bring a gradual increase in prices. This is also reflected in the partial recovery of the fleet growth. However the fleet growth continuously lags behind that of demand, even though the

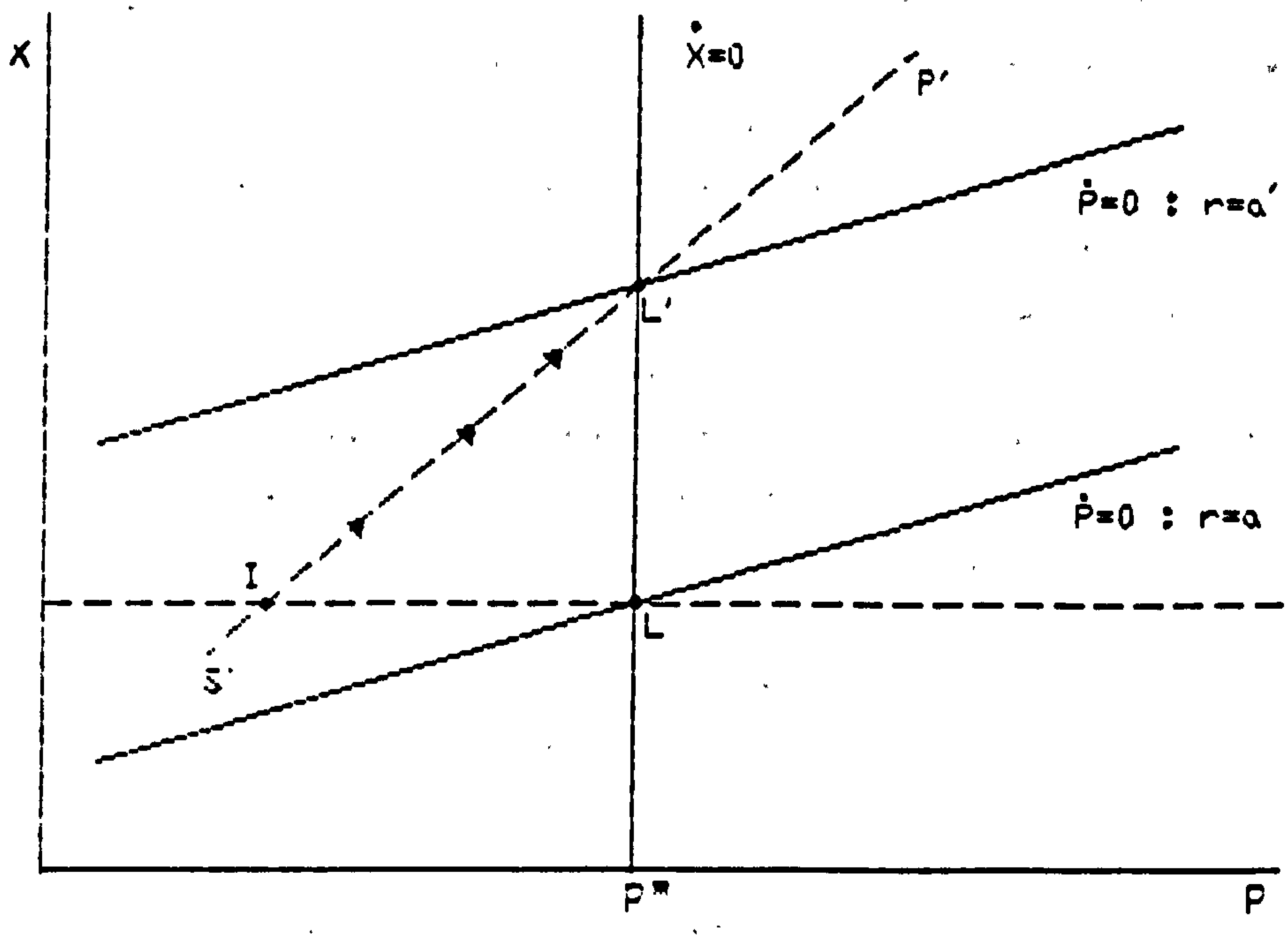

Fig. 3.18 : Unanticipated increase in returns to capital

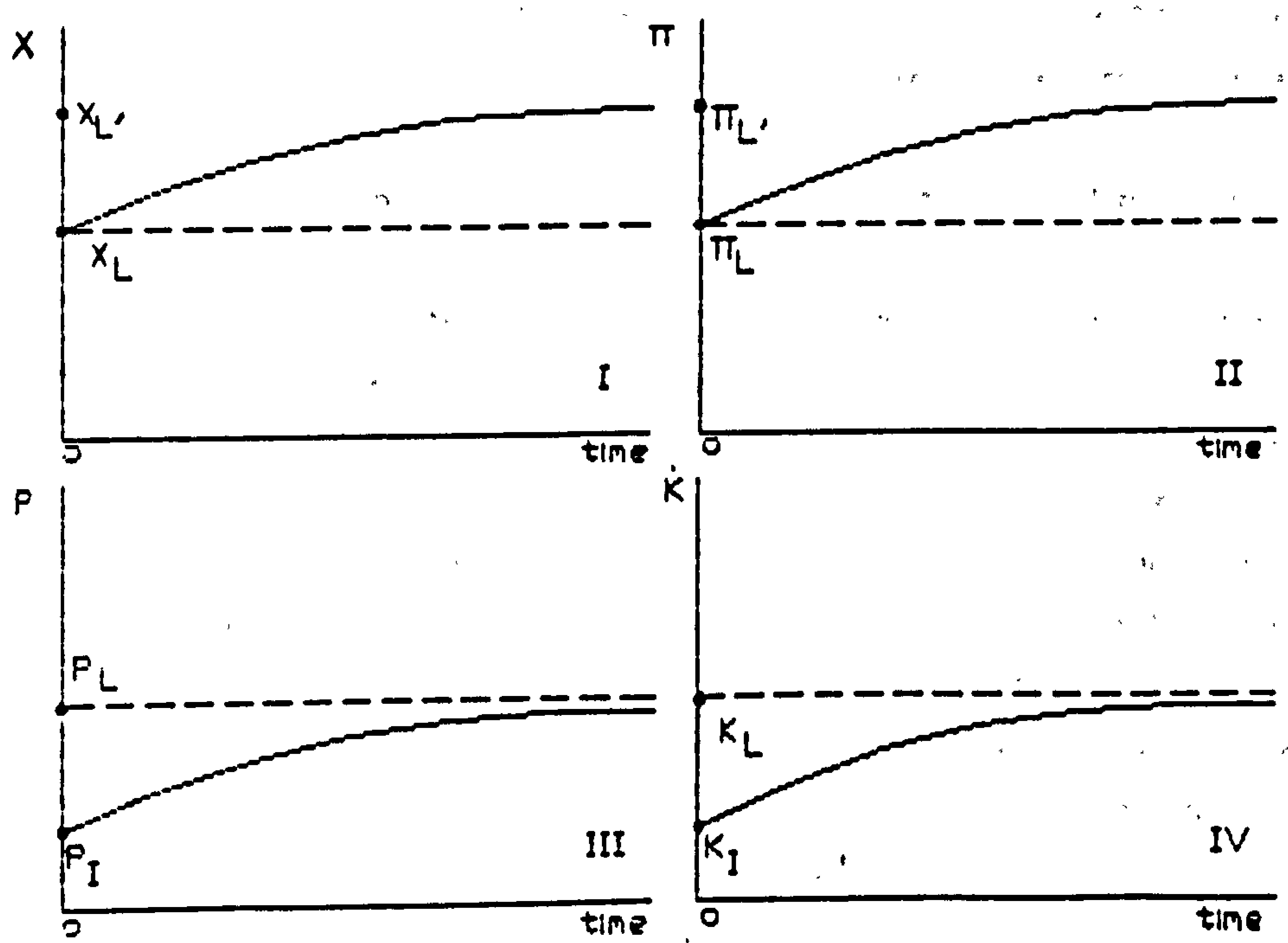

Fig. 3.19 : System's response to returns to capital shock

gap is continuously closing. The former implies that the freight market balance and profits continue to improve. The latter implies that the improvement begins to decelerate. The recovery in profits, leads to a recovery in prices and thus in the increase of the fleet. Eventually profits increase to an extent that prices and fleet growth return to the base run level. Meanwhile the previous slowdown in fleet growth leads to a permanent improvement in market balance and profits but not prices. This is because the higher profits are now more heavily discounted.

Again here prices and fleet growth rate, initially overshoot their long run equilibrium level.

3.7.6 *"Speculative Bubble Burst"*

It shall now be assumed that initially ship prices are at a different level than the one required to set the system on the saddle path. In our base run the stable equilibrium requires that the system should be initially at point L with prices at a level P^* in fig. 3.20. Given the base run assumptions, this will imply that the system will remain at rest for ever at point L.

Let it be assumed that because of some irrationality prices are initially higher than P^* as at time 0 the system finds itself at point A. This higher price brings down the yield. Thus investors will pay this high amount of money only if prices are rising strongly at A in order to maintain the return at a competitive level. Because of the higher prices there is more shipbuilding and less scrapping so the fleet is growing more rapidly than demand. The latter implies a worsening freight market balance and lower profitability in the next period. The high price together with the drop in profitability therefore requires even higher capital gains in the next period in order to keep the return at the equilibrium level. This implies even higher fleet growth rate and lower profits in the following period and so on. Thus an unstable exploding path emerges if the initial

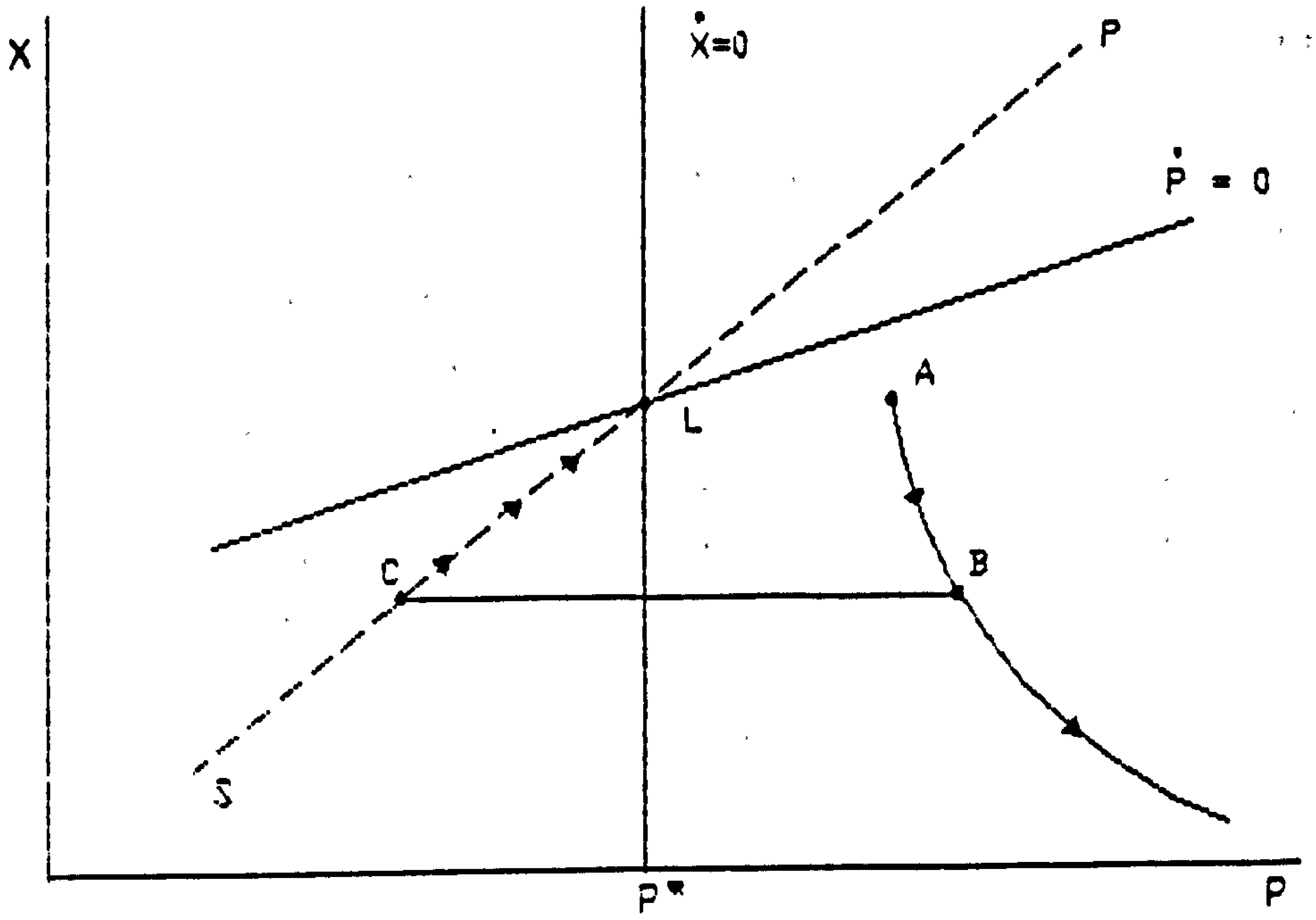

Fig. 3.20 : Speculative bubble

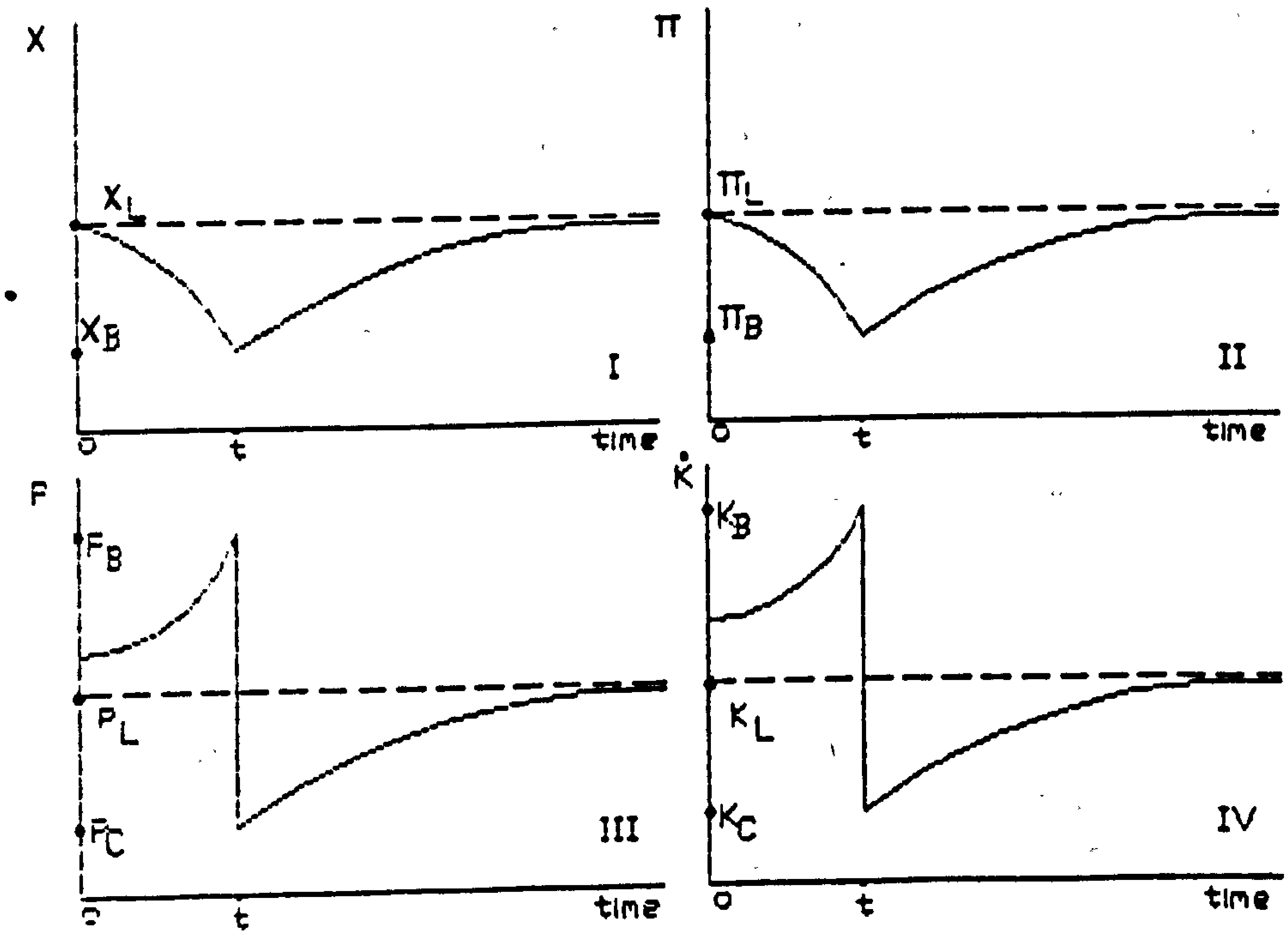

Fig. 3.21 : Speculative bubble path

overpricing is to be justified. In fig. 3.20 this is represented by the curve through point *A*.

It can be seen that along the bubble path ship prices explode to infinity without regard to profitability. The latter collapses as the fleet explodes in line with ship values. The initial overpricing can only be justifiable to investors if prices follow this exploding path. The system should move from point *A* towards point *B* and then continue towards the south east direction as the arrows indicate, unless the bubble bursts. Loosely speaking, such a path can be interpreted as a case were investors believe that ship values have acquired an accelerating momentum and a life of their own which allows a return to be earned because of the strong capital gain component and in spite of the resulting insignificant profitability. If investors believe this path will be followed then it can become a self fullfiling prophesy as the capital gains keeps every investor satisfied.

In the previous sections the system's behaviour was analysed assuming that there are no 'bubbles'. It is debatable whether 'bubbles' appear in actual practice. In the real world ship values seem to fluctuate within finite bounds . and eventually they return to the level suggested by the underlying long run freight market profitability. This suggests that even though 'bubbles' might appear in the short run, they do not last for long i.e they eventually burst. Let us therefore consider the time of path of the system when a speculative bubble develops which is followed by a burst that sets the system on the convergent path.

Let us say therefore that the system begins initially from point *A* and travels along the unstable path through *A* until at some point the bubble bursts. The latter is assumed to happen at some point in time t when the system reaches point *B*. To set the system on the convergent path the market must move to point *C* which implies a collapse in ship values as the system moves from *B* to *C* which lies on the saddle path *SP*.

At *C* ship values are lower than at *L* or *B* and thus so is shipbuilding, while scrapping is higher. Thus the initial overpricing at A and the excessive fleet growth that occurs while the system moves from A to B must be followed by a correction phase were prices collapse and this chokes off shipbuilding and stimulates scrapping. This is needed in order to cancel the speculative increase in the fleet so as to move the system back ot the long run equilibrium point L. As the system moves from C to L, with values always lower than at the long run level, the excess fleet size which was build up during the bubble period is eliminated during this depression phase. This allows the market to approach its long run equilibrium. The collapse in values from B to C implies a loss of money for investors who hold ships at that time.

In mathematical terms the second hand market equilibrium condition breaks down temporarily at the moment of the correction. The big capital losses made at that moment provides us with an economic rationale for assuming that investors will avoid the development of such bubbles for fear of a burst. This is the assumption that was made in the previous sections.

Fig. 3.21 translates the phase diagram movements onto a time scale. It can be seen that initially the bubble increases prices to the unsustainable level P_A . This also increases the growth rate of the fleet to K_A . As a result the freight market balance and profitability worsens. As long us the bubble lasts, prices continue to increase and so does the fleet growth. This causes the freight market balance and profits to fall further. At time t the bubble bursts and prices collapse from a level P_B to a lower level P_C . The fleet growth also drops instantaneously from an all time high level of K_B to an all time low K_C . As a result the market balance and profits begin to improve. As profits rise, prices begin to recover from their lows. There is thus a deceleration in the speed with which the freight market is improving. Eventually x, π, P, $\dot{K}$ return to the base run level and the effects of the bubble disappear in the long run.

3.8 Anticipated Shocks

In this section the system's reaction to shocks which are anticipated by the market before they occur will be considered. An identical base run will be used for the purposes of the simulations. Thus under the simple base run the system is in long run equilibrium with the fleet growing at the same rate as demand and profits, market balance and prices are constant. Then the system's equilibrium path is calculated under the assumption that at time t (t≠0) there is a change in one of the exogenous variables similar to the ones considered in the previous section. Here however the shock is not unexpected but the market is assumed to foresee it at time 0. Again 'bubbles' are ignored throughout the whole of this section and it is assumed that prices are set purely on the basis of economic fundamentals. The convergent stable solution of the system will be calculated under the base run assumptions and subsequently under the assumption of the shock. Use will be made of the fact that near the intersection of the two loci the speed of motion becomes very slow while further away from this point the speed of motion becomes faster.

3.8.1 Permanent anticipated increase in growth rate of demand

In the previous section it was seen that an increase in the growth rate of demand from say some level g to a higher level g' shifts the $\dot{x}=0$ locus to the right. Here the shift occurs at time t when the shock occurs. However the market reacts at time 0 when the shock is realized by the market. Fig. 3.22 shows the position of the $\dot{x}=0$ locus before and after the anticipated shock. The vertical line $\dot{x}=0:\dot{q}=g$ through L represents the position of this locus before the shock while at time t this shifts to the position indicated by the line $\dot{x}=0:\dot{q}=g'$ through L'. There is also a new saddle path $S'P'$ curve through L'.

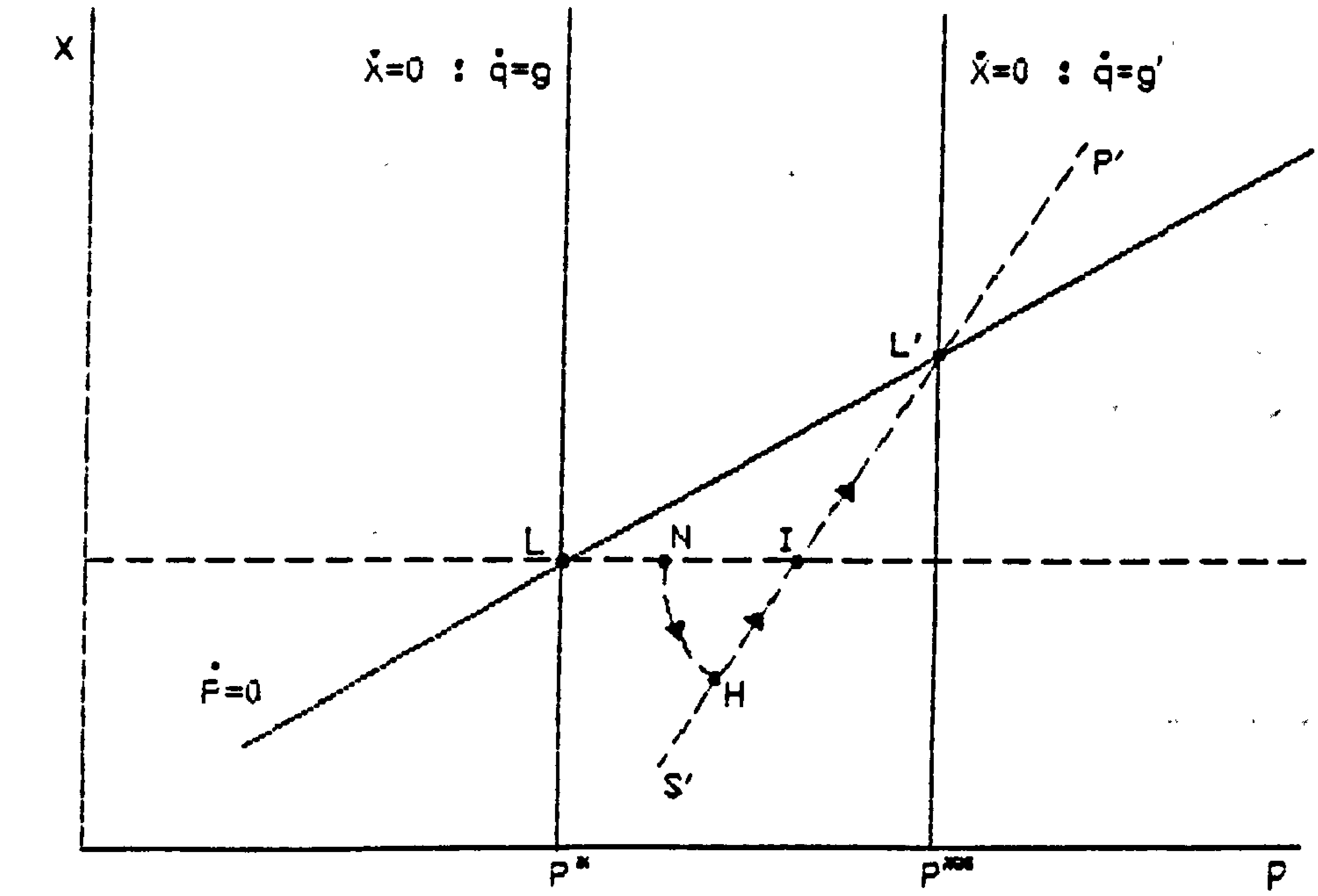

Fig. 3.22 : Anticipated increase in demand growth rate

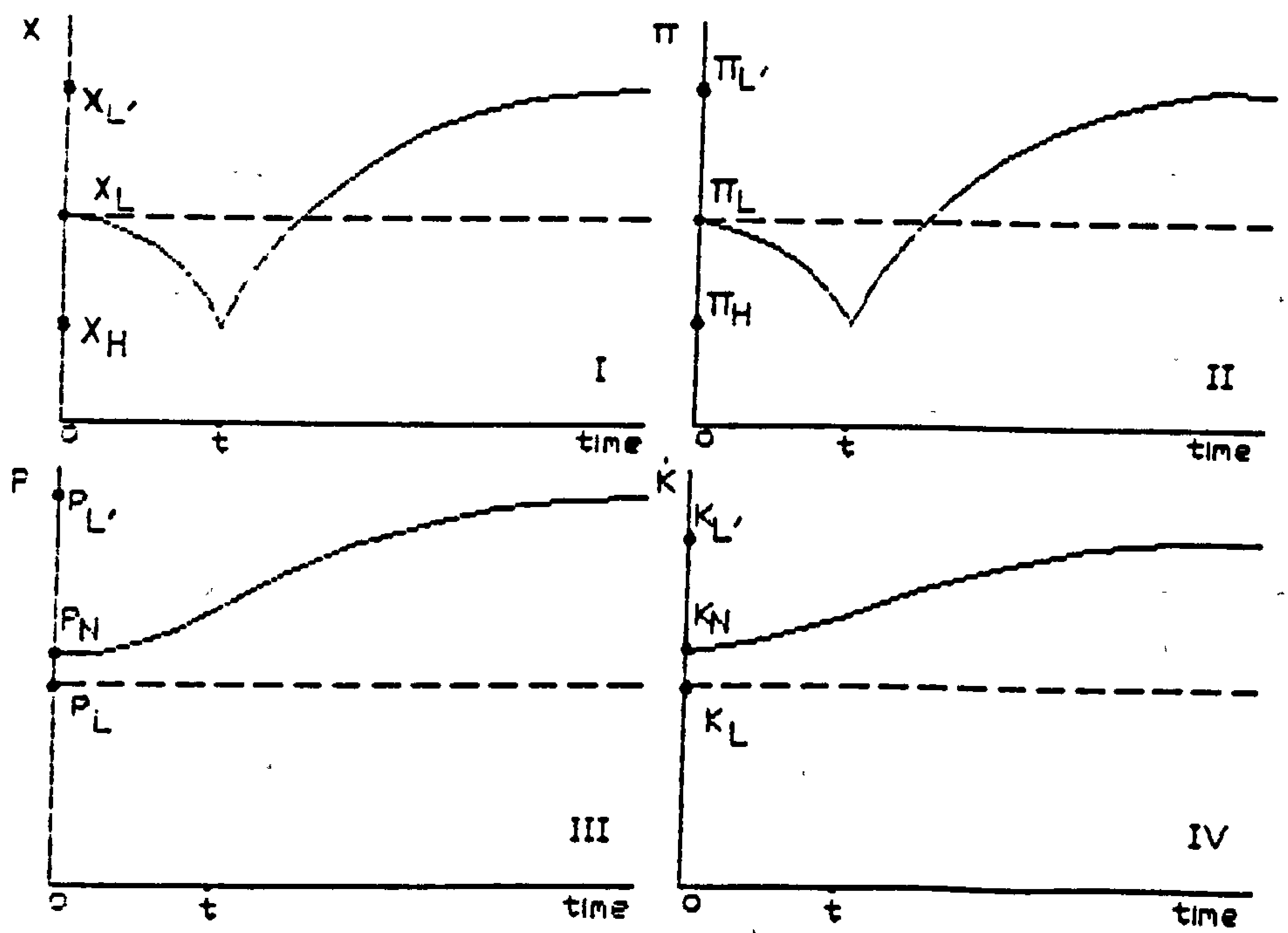

Fig. 3.23 : System's response to demand growth shock

When the shock was completely unanticipated (i.e t=0) the initial market equilibrium was at point I. Now that the shock is anticipated the market can react before the actual increase in $\dot{q}$ takes place and this dampens the future effects of the shock. In addition there is discounting of the future benefits of the shock. Thus initially the speculative jump in values is smaller than in the anticipated case. Thus at time 0 the system moves to some point in between L and I such as N. This implies a smaller initial jump in ship values.

The direction of motion of the system at some point in the x,P can be determined by its relative position to the two loci. Up to time t it is the two loci through point L that are relevant while after time t the phase dynamics are determined by the two loci through point L'. Thus up to time t the system moves along the NH segment in the direction of the arrows. At time t the market finds itself at point H which lies on the new saddle path through L'. Indeed the initial equilibrium at point N is determined by this requirement that at time t the market should find itself on the new saddle path. From time t onwards the market moves along the segment HL' in the direction of the arrows.

Fig. 3.23 translates the comovements of x, π, P, $\dot{K}$ onto a time axis. It can be seen that at time zero when the market learns about the future shock, prices jump from a level P_L to a level P_N. The growth rate of the fleet also responds in the same way as the higher prices bring forward a higher newbuilding supply and at the same time they restrain scrapping. Thus the fleet begins to grow faster than demand. The increase in the growth rate of demand has not as yet occurred and thus the freight market balance and profits begin to drop. The increases in the fleet are accumulated and thus market balance falls further with the passing of time. As time moves closer to t there are further speculative gains in prices as the turning point in freight market becomes more imminent and is thus less heavily discounted. This further increases the size of the fleet and depresses the freight market. Thus the freight market is at an all time low just before the occurrence of the shock because of the accumulating continuous increases in the size of the fleet that have taken place.

From time t onwards the fleet continuous to grow at a high rate but now demand growth rises to an even higher level g' and thus the freight market gap created during the initial speculative build up, begins to close. Freight market balance and profits begins to recover. This causes prices and fleet growth to rise futher. These changes are supported by the higher demand growth which runs faster than that of the fleet. At some point in time after t, market balance and profits rise above the base run level and this is what justifies the initial speculative rise in values. The further increases in profits and prices cause an additional increase in the fleet growth which moves closer to g'. Thus market balance continuous to improve but at a slower rate, after rising above the base run level. Eventually profits and prices rise to such an extent that the fleet growth catches up with that of demand and the market settles on a long run equilibrium. This long run equilibrium involves higher fleet growth (g'), higher prices, higher freight market balance and profits.

3.8.2 Permanent anticipated increase in bunker prices

An increase in bunker prices from a level a to a higher level a' will shift the $\dot{P}=0$ locus to the right without affecting the $\dot{x}=0$ locus. Fig. 3.24 shows the position of the loci before and after the shock. The position of the $\dot{P}=0$ locus prior to the shock is represented by the $\dot{P}=0{:}P_b=a$ line through L while after the shock its new position is represented by the $\dot{P}=0{:}P_b=a'$ line through L'. There is a new saddle path through L' which is denoted by $S'P'$.

It was seen in the previous section that if the shock is unanticipated the initial equilibrium will be point I. Now that the shock is anticipated the fleet will react before the increase in bunker prices takes place and this

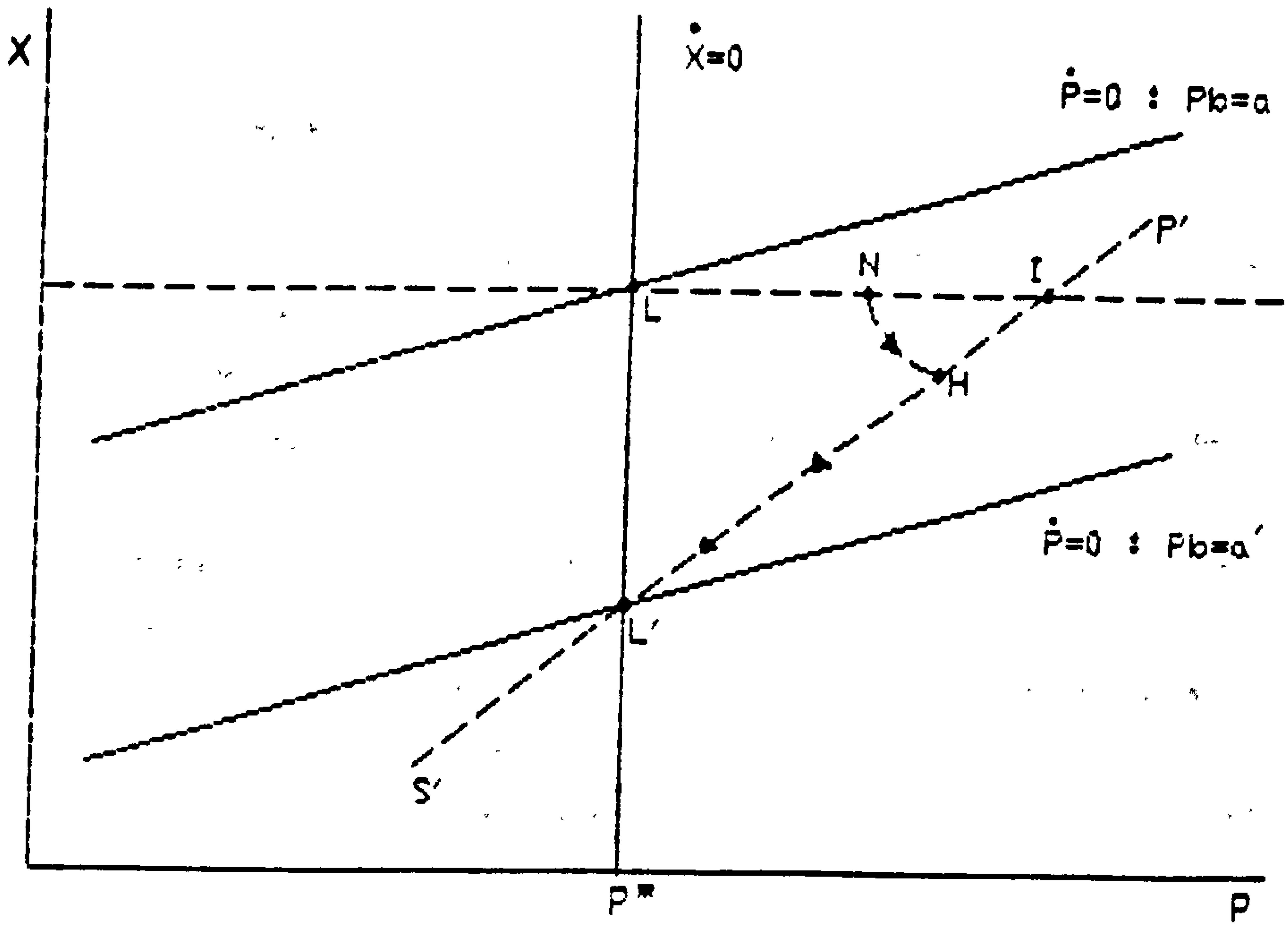

Fig. 3.24 : Anticipated increase in bunker prices

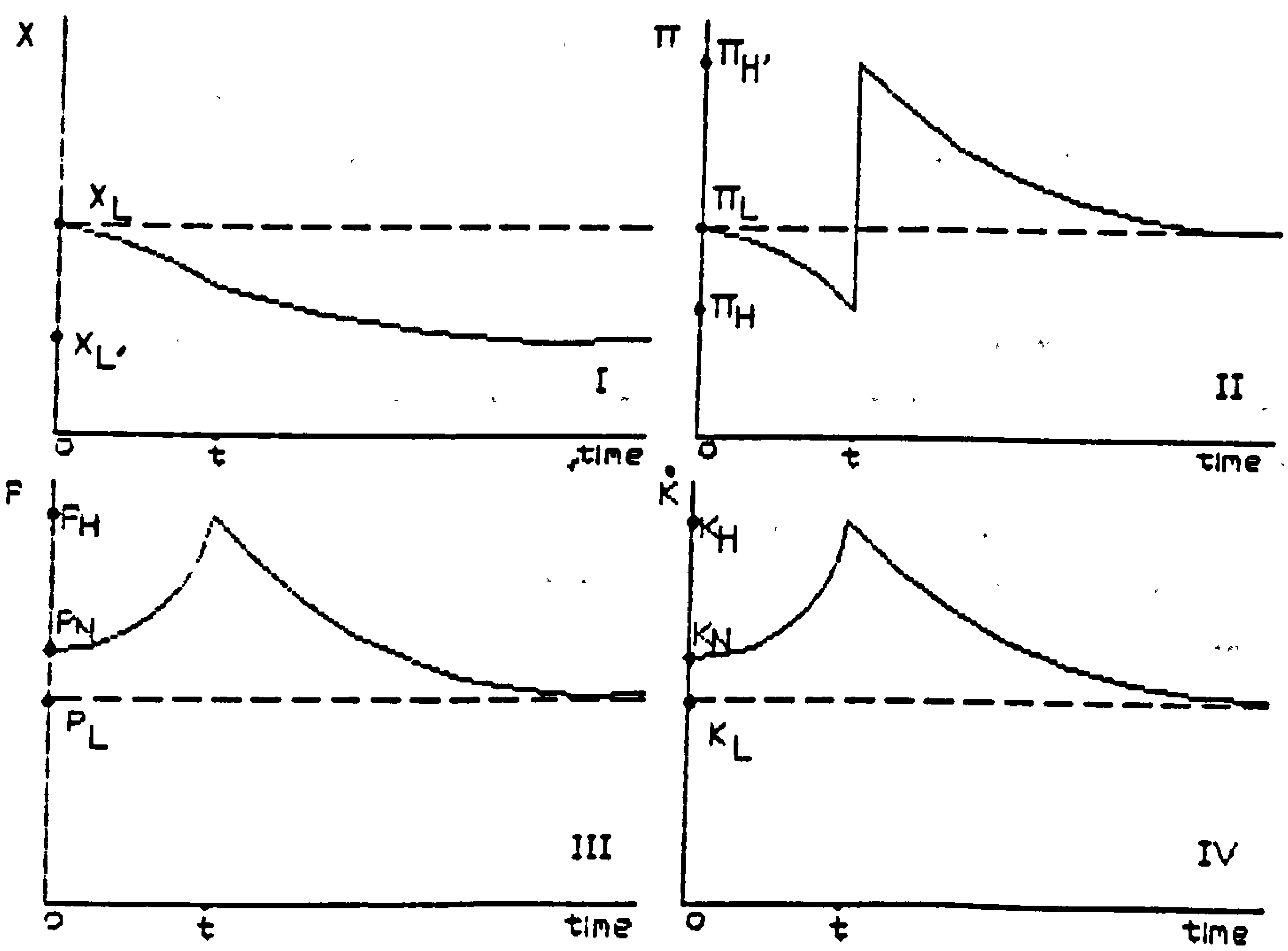

Fig. 3.25 : System's response to bunker price shock

will dampen the effects of the change. In addition there is discounting of the future effects which further restrains the initial speculative jump in values. Thus the system will initially move at a point in between L and I such as N.

From time 0 up to time t the system will be moving along the segment NH. At time t the system moves to point H which lies on the new saddle path. From then on the market moves in a different direction as the shift in the $\dot{P}=0$ locus changes the phase dynamics. The market begins to move from point H towards point L' in the direction of the arrows.

Fig. 3.25 translates the phase movements onto a time axis. It can be seen that initially prices jump to P_N and parallel to that the fleet growth moves to K_N. The faster increase in the size of the fleet causes a deterioration in the freight market balance. Bunker prices have not increased yet and thus profitability falls in line with x. Prices increase further as time passes by and this causes further expansion of the fleet and deterioration of the freight market balance. The increases in the fleet are accumulated and thus the freight market profitability reaches an all time low just before the occurrence of the shock.

At time t, bunker prices increase and this induces an incentive to slow steam. This creates an artificial freight market shortage. Because demand is completely inelastic the increase in costs is completely past over onto the shippers and thus profitability increases. Indeed at time t the profitability jumps from its all time low level π_H to an all time high $\pi_{H'}$. The increase in fuel prices causes profits to increase above their base run level in spite of the speculative increase in the size of the fleet. This pattern does not depend on any other assumptions about elasticities. When speculation is informed, any tendency for the fleet to grow too fast, causing a bigger restrain in profits, leads to speculative corrections in prices that prevent this from happening. From time t onwards, the higher prices cause a further increase in the size of the fleet and thus a further drop in x. Thus profits begin to recede from their all time high level. This causes a turning point in prices and fleet growth. Prices are at an all time high at t where the profit prospects are at their best. After time t the increase in fleet size bring profits and prices down towards the base run level. This also helps to bring the growth rate of the fleet down towards the base run level. Freight market balance continuously drops until the system moves to a new long run equilibrium. The effects of the bunker shock on profits, prices and fleet growth disappear in the long run. There is however a permanent drop in x which reflects permanent slowsteaming. Because of the temporary shipbuilding boom there are more ships to satisfy the given level of demand.

3.8.3 Permanent anticipated increase in shipbuilding costs (or scrap prices)

An increase in shipbuilding costs or scrap prices have similar effects on the time path of the system. Thus the analysis will be carried assuming an increase in shipbuilding costs from a level a to a higher level a' has taken place having in mind that similar time paths would arise if there had been an increase in scrap prices. The effect of an increase in P_1 is to shift the $\dot{x}=0$ locus to the right. In Fig. 3.26 the position of this locus before the shock is represented by the $\dot{x}=0: P_1=a$ line through L while its position after the shock is represented by the $\dot{x}=0: P_1=a'$ line through L'.

If the shock is unanticipated the system moves on to point I initially. When the shock is anticipated the initial speculative increase in values is lower as the system has time to react and as the effects of the shock will be mainly felt in the more distant future which is more heavily discounted. Thus at time 0 equilibrium will be established at a point such as N which lies in between L and I.

From time 0 onwards the system will move from N

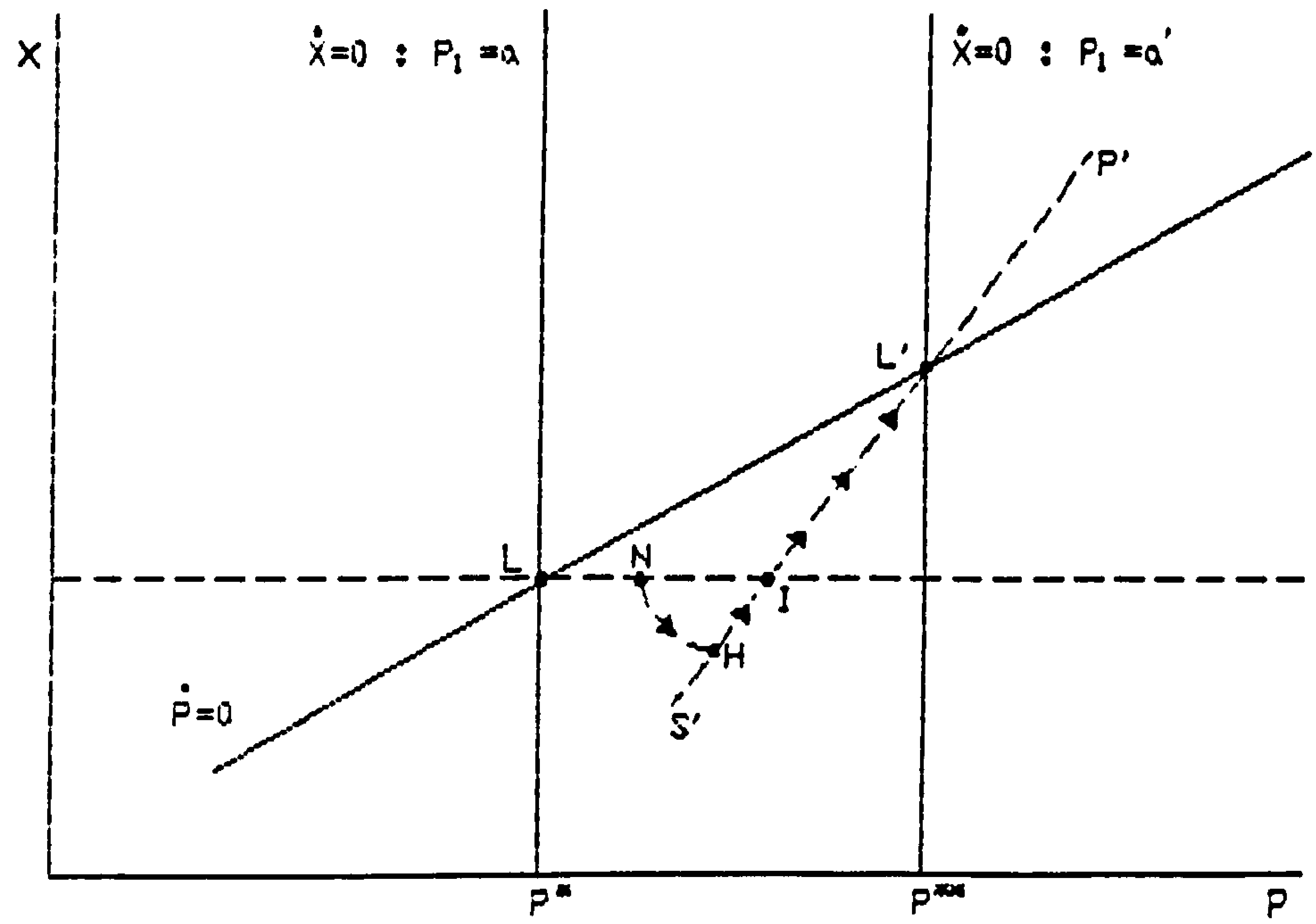

Fig. 3.26 : Anticipated increase in shipbuilding costs

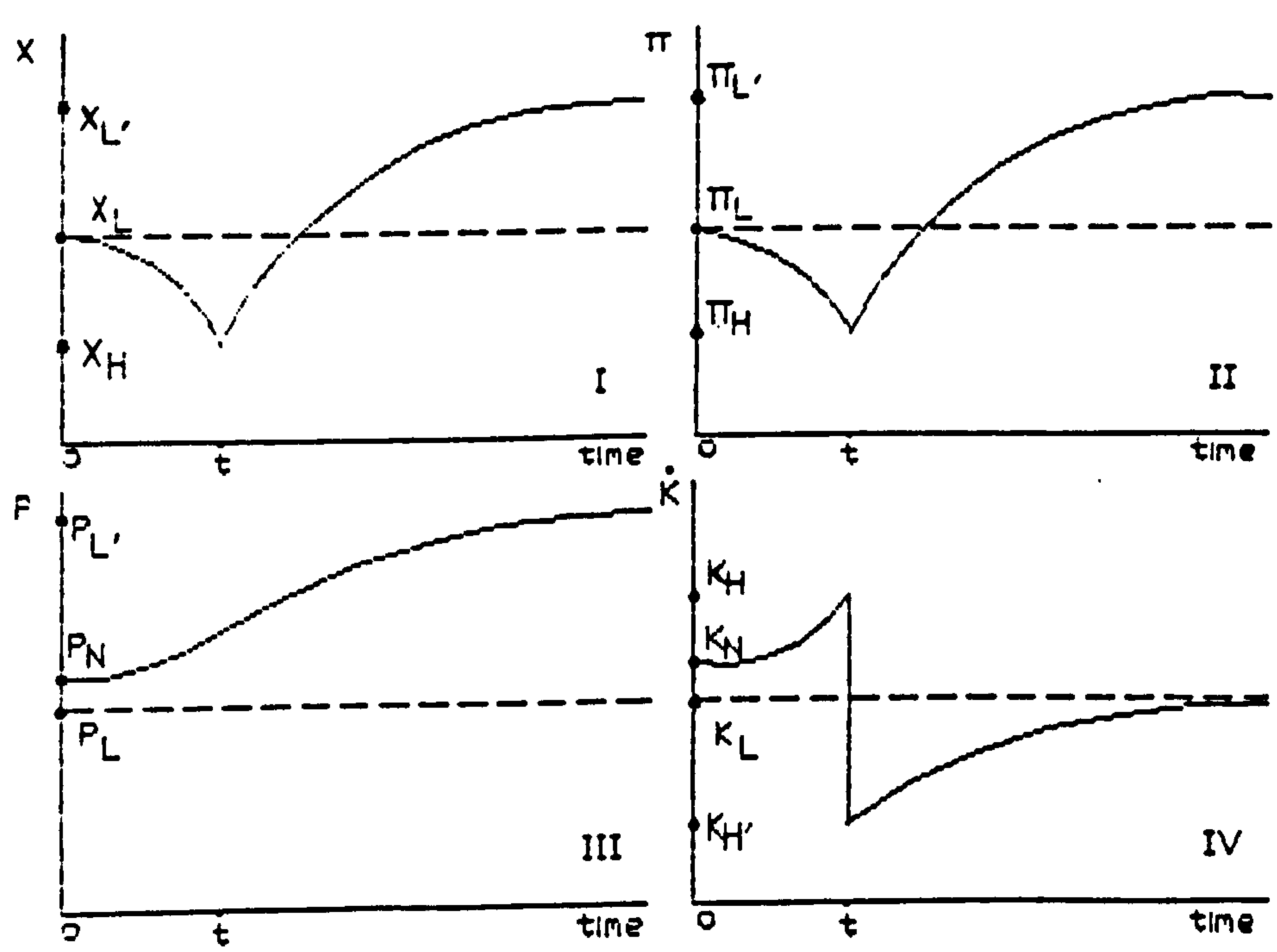

Fig. 3.27 : System's response to shipbuilding cost shock

towards H in the direction of the arrows. It will reach point H which lies on the new saddle path $S'P'$ at time t when the shock occurs. The increase in shipbuilding costs at t will cause a shift in the $\dot{x}=0$ locus which affects the phase dynamics at any point including H. Thus after time t the system changes direction and begins to move from H towards the long run equilibrium point L' in the direction of the arrows.

Fig. 3.27 shows the fluctuations in x, π, P, $\dot{K}$ before and after the shock. The realization of the shock leads to an initial speculative increase in values from P_L to P_N. This causes the growth rate of the fleet to expand since shipbuilding costs have not as yet risen. As a result the freight market becomes depressed. This depression deepens over time as the increases in the fleet size are accumulated. As time t is approached and the market moves closer to the point where the higher costs will restrain the fleet size there are further speculative gains in values. This further depresses the freight market.

At time t the increase in costs occurs and the shipbuilding supply immediately contracts. As a result the growth rate of the fleet collapses from its all time high level K_H to an all time low $K_{H'}$. The increase in costs completely cancels the positive effects of the higher ship values on the supply of new ships and the fleet growth drops below the base run level. This implies that the freight market and profits begin to turn at time t. Eventually they increase above the base run level and this is what justifies the initial speculative increase in prices. This makes room for further gains in values as the fleet growth remains below that of demand. However as long as this lasts there are continuous improvements in market balance and profits which eventually raise prices to such an extent that fleet growth rate recovers to the base run level. From t onwards the fleet lags behind demand to such an extent that it completely cancels out the gains in fleet size that were achieved before time t. This causes a permanent increase in freight market balance, profits and prices. These are needed in order to cancel the permanent restraint of the higher costs on the supply of new ships so as to raise the fleet growth back into line with that of demand.

The efficiency of the system can again be be seen from the time pattern of the fluctuations. Initially and while costs have not increase the system builds more ships while they are still cheap. When costs increase, expensive construction is held back and future demand is satisfied with a lower fleet size and higher speed and consumption of fuel the price of which is still the same.

3.8.4 Permanent anticipated increase in alternative returns to capital (r)

An increase in returns to capital r from a level a to a higher level a' will shift the $\dot{P}=0$ locus to the right while at the same time it will leave the position of the $\dot{x}=0$ locus unaffected. These movements are shown on fig. 3.28. Prior to the shock the position of the $\dot{P}=0$ locus is indicated by the upward sloping line $\dot{P}=0: r=a$ line through point L. When the increase occurs this shifts to the right to a new position indicated by the line $\dot{P}=0: r=a'$ through point L'.

In the case were the shock was unanticipated the initial equilibrium was at point I. Now that the shock is foreseen the speculative drop in values is necessarily lower so the system moves to a point such as N which lies in between I and L.

Fig. 3.29 shows the fluctuations in x, π, P and $\dot{K}$ that arise as a result of this shock. There is an initial speculative drop in values from P_L to P_N as the positive effect of the future profitability is more than cancelled by the more heavy discounting. This drop is restrained by the fact that the lower price will lower the fleet growth which implies higher future profits. Indeed the fleet growth drops initially from the base run level K_L down to K_N. This causes the freight market balance and profits to improve. As time t is approached the discounting of future profits becomes even more heavy as there is less

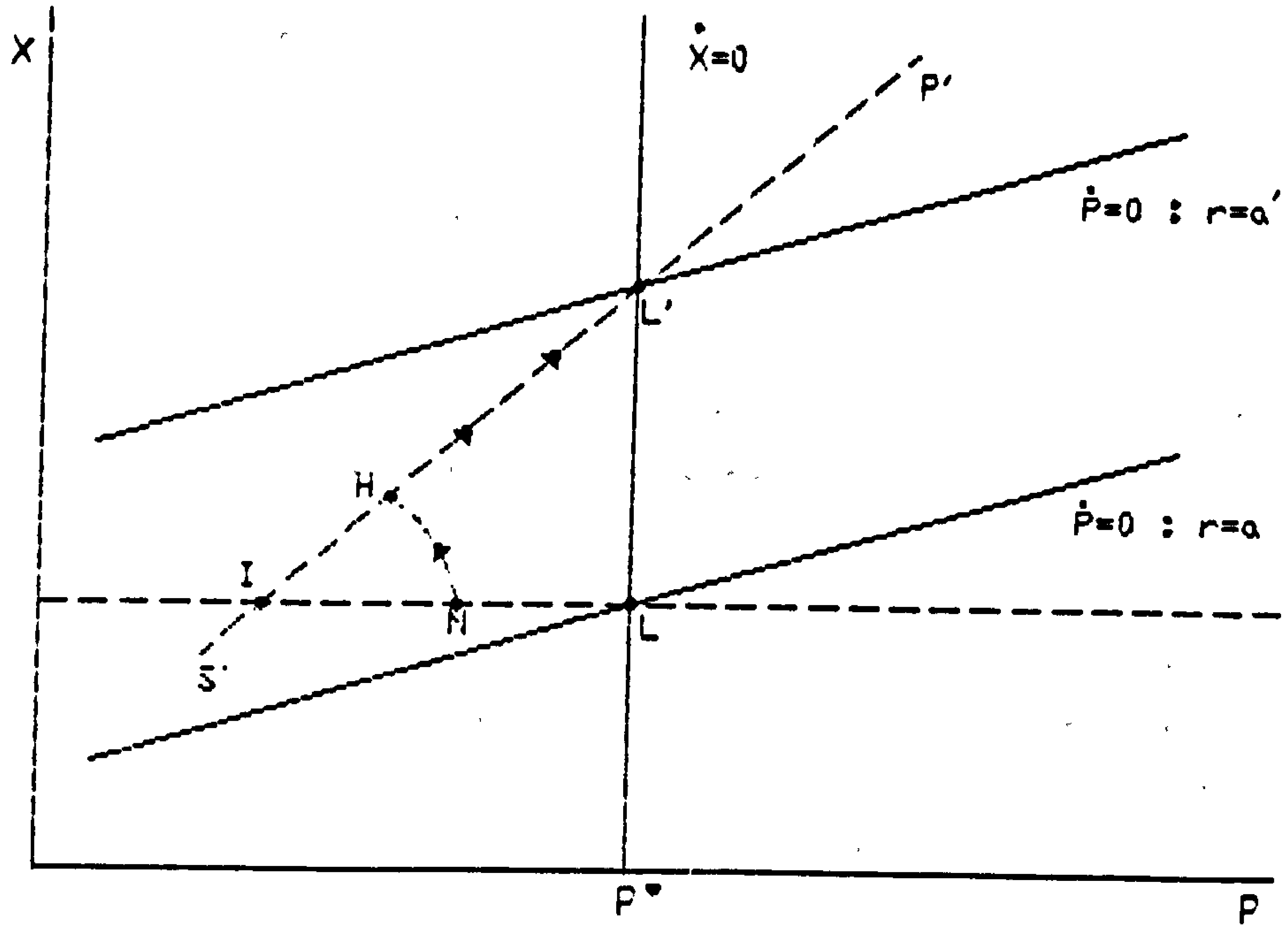

Fig. 3.28 : Anticipated increase in returns to capital

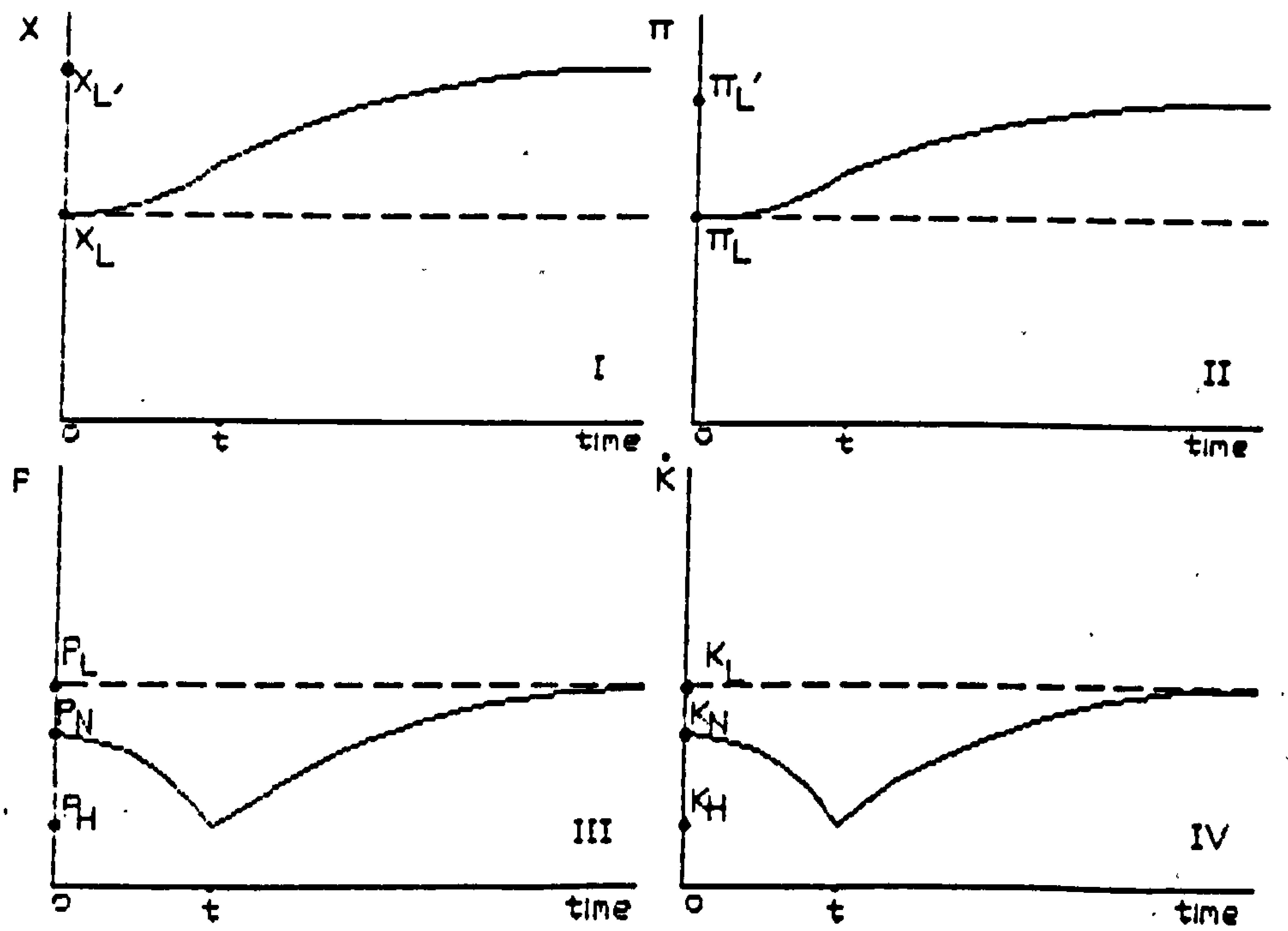

Fig. 3.29 : System's response to returns to capital shock

time left before the increase in r' materializes. This cancels out the positive effects of the improvements in the profit profile outlook and thus prices drop further. This causes a further drop in the fleet size and thus additional freight market improvement.

At time t, r increases and discounting reaches its heaviest point and remains at that level from then onwards. Thus there is no additional negative effect on prices from further increases in discounting and thus the further improvements in profitability cause a gradual improvement in ship values. Thus t is the turning point for prices and the fleet growth. The latter however still remains below base run level and thus there are further gains in market balance and profits. These help prices to recover closer to the base run level. In the long run the cutbacks in the size of the fleet cause profits to increase to such an extent that prices return to the base run level and so does fleet growth. There is no long run effect on prices and fleet growth. However there are permanent increases in freight market balance and profits.

3.9 Concluding remarks

In this chapter a simple theoretical model of a hypothetical shipping industry was developed. For this purpose the behaviour of economic agents at the micro level was analysed first. This was used in order to derive demand and supply curves in the various markets. These were the building blocks of the macro model. The model was used in order to analyse how equilibrium rates, profits, ship values, shipbuilding and scrapping are determined in terms of a set of external factors which includes the level of demand, fuel prices, returns to capital, shipbuilding costs and scrap prices. A central position in the theoretical model is occupied by the behaviour of investors whose expectations are assumed to be rational. Thus investors can take speculative positions in response to future expected impulses and this affects the current state of the market. Speculative changes in prices will then force the fleet to respond through changes in the supply of new ships and scrappings. The supply of new ships is then absorbed by an infinitely elastic demand for assets. This mechanism differs significantly from the one embodied in existing models of the shipping markets. There the size of the fleet is mainly driven by oscillations in a downward sloping demand for new ships which responds in a rather ad hoc backward looking way to trends in demand for shipments and freight rates.

Sections 3.6 - 3.8 analysed the effects of changes in the external factors on the equilibrium path of the system by means of simulations of the theoretical model. It can be seen that the simulated cycles exhibit various patterns that differ according to the type of external shock to which the market is subjected. Chapter 1 considered the correlations and patterns exhibited by actual historical cyclical episodes. The stylized facts of a representative historical cycle, which is normally generated by a sudden and unexpected spurt in demand, were found to be the following.

The increase in demand is associated with an improvement in the freight market balance which is followed by significant reductions in lay-up and strong increases in freight rates, time charter rates and profits. This also coincides with a significant improvement in second hand and newbuilding prices. Scrapping decreases immediately and the order book expands. Because the extra orders can not be delivered immediately, the increase in freight rates lasts for some time. After a few months months however the growth rate of the fleet expands rapidly as the new orders become deliveries. This leads to a period of recession where freight, time charter rates and profits are falling while lay-up increases. Ship prices also fall and this is followed by an increase in scrapping and a recession in shipbuilding.

It can be seen from Fig. 3.11 that these broad patterns of a real world cycle can be reproduced by the model's simulations of the effects of an unanticipated demand shock. The simulations reproduce positive correlations between market balance, rates, profits, prices, shipbuilding and fleet growth and the negative correlation of these factors with scrapping rates that are observed during a real cycle. This provides some support for the validity of the theory as a tentative explanation of the cyclical behaviour of the industry.

CHAPTER 4

THE DRY CARGO MODEL

The theory of chapter 3 is used as a basis in order to specify and estimate an econometric model of the world dry cargo market. The empirical results are consistent with a priori expectations regarding the signs and values of various elasticities of supply and demand curves.

The estimated model is used in order to simulate the market's response to various anticipated and unanticipated shocks. Historical simulations of the freight market submodel are also presented and it is found that these track actual developments quite accurately.

4.1 Introduction

In the previous chapter we presented a theory of shipping markets based on the assumption of optimizing behaviour of economic agents in each market. In this chapter the theory is used as a basis to develop an econometric model of the dry cargo market. Econometric versions of the theoretical equations derived in the previous chapter are specified. The unknown parameters of these equations are estimated using data from the post World War II period. In the next chapter the same theory is applied to the tanker sector and an econometric model is estimated using data from the same period. In chapter 6 an econometric model of the world shipping market is developed by linking the two individual models of the dry cargo and tanker markets.

The theoretical model analysed in the previous section, captures the fundamental endogenous interactions between the freight market and the markets for ships. In order to add explanatory and forecasting power to the model, certain simplifying assumptions made in the previous chapter must be relaxed. Thus the model is extended to take account of additional exogenous influences in each market as well as dynamic complications. It is also desirable to dissagregate slightly and distinguish between various dry cargo ships either by type or age. The extensions introduced and the level of aggregation chosen reflect a balance between, on the one hand, the likely improvements that would follow from this and, on the other hand, the wish not to complicate the model unnecessarily.

Some of these modifications do not simply of consist of adding a few additional exogenous and lagged variables into the equations already specified in chapter 3. Adding realism to the model necessitates the specification of a new set of equations which capture completely new aspects of behaviour which up to now have been ignored. For example the determinants of lay-up, time charter rates, fleet age profile and length of the order book have not yet been considered.

Plan of chapter 4

Section 4.2 contains an overview of the underlying economic theory and the associated system of equations, econometric versions of which are to be estimated subsequently. The underlying theory is really an extension of the one presented in the previous chapter. The theoretical overview places particular emphasis on those aspects of behaviour that have up to now been ignored while theoretical issues that have already been dealt with are only briefly summarised. Section 4.3 introduces the econometric methodology used and then presents and discusses the econometric estimates. In section 4.4 the econometric model is used in order to simulate the effect of various anticipated and unanticipated shocks and thus its dynamic multipliers are derived. Finally section 4.5 presents historical simulations of the dry cargo freight market model.

4.2 Overview

The dry cargo model consists of a freight market, second hand, newbuilding and scrap market. It solves for the equilibrium level of freight rates, time charter rates, second hand and newbuilding values, orders and deliveries, scrapping, the age profile and the size of the fleet. This section presents the theoretical specification to be estimated which is derived from the theoretical analysis of chapter 3 after being appropriately modified to take account of additional real world phenomena.

The theoretical specification of the model is listed on Table 1.

Table 4.1

Model Listing

$$q^s = F_1(Kv,\ F/Pb,\ Z_q) \quad (1)$$

$$Kv = (1-\lambda)K + p_d K_c \quad (2)$$

$$\lambda = F_2(\ F,\ Pb,\ OC,\ LC) \quad (3)$$

$$q = q^s \quad (4)$$

$$\pi_t = k(F_t^{1+\gamma})/(Pb_t^{\gamma}) - OC_t \quad (5)$$

$$lnH_t = (1+\gamma)E_t lnF_{t+1} - \gamma E_t lnPb_{t+1} + \mu \quad (6)$$

$$P_t = F_4(\ W_t/K_t,\ E_t\pi_{t+1},\ E_t P_{t+1},\ r_t) \quad (7)$$

$$Q = F_5(\ Pn,\ Pn',\ Pl,\ Pl';\ Z_Q) \quad (8)$$

$$D_t = \sum_{i=1}^{m} w_i Q_{t-i} \quad (9)$$

$$Pn_t = E_t P_{t+1} + k \quad (10)$$

$$s_i = F_6(\ P/Ps) \qquad i = 3,4,5 \quad (11)$$

$$s = A_3 s_3 + A_4 s_4 + A_5 s_5 \quad (12)$$

$$S = Ks \quad (13)$$

$$A_{2,t}K_t = A_{1,t-5}K_{t-5} \quad (14')$$

$$A_{1,t}K_t = \sum_{j=0} D_{t-j} \quad (14'')$$

$$A_{i,t}K_t = A_{i-1,t-5}K_{t-5}\left(\ 1 - (1/2)\sum_{j=1}^{5} s_{i,t-j} - (1/2)\sum_{j=1}^{5} s_{i-1,t-j}\right)$$

$$i = 3,4,5 \quad (14''')$$

$$K_t = K_{t-1} + D_{t-1} - S_{t-1} \quad (15)$$

4.2.1 Freight Market

Supply

Supply in the freight market given the technology depends on the size of the fleet trading in the dry cargo markets, the speed of the fleet and various inefficiency parameters such as waiting time in port and the proportion of time spent in ballast or repairs. The speed of the fleet depends on the ratio of freight rates to unit voyage costs which are a weighted average of the price of bunkers and port charges. Hence:

$$q^s = F_1(\overset{+}{Kv}, \overset{+}{F/Pb}, Z_q) \qquad (1)$$

where

q^s = Supply of dry cargo ton-miles

Kv = Fleet trading in the dry cargo market

F = Dry cargo voyage freight rate

Pb = Index of unit voyage costs

Z_q = Vector of exogenous variables that might additionally influence the supply of ton - miles

Our notation is the same as in the previous chapter. The size of the fleet trading in the dry cargo freight market excludes the dry cargo ships that are laid up but includes combined carriers in dry. Thus

$$Kv = (1-\lambda)K + p_d Kc \qquad (2)$$

where

λ = Proportion of dry cargo ships laid up

K = Dry Cargo Fleet

p_d = Proportion of combined carriers in dry

Kc = Combined carrier fleet

Combined carriers are versatile ships which can carry either oil or dry bulk cargo. They switch between the tanker and the dry cargo freight market according to the relative profitability of trading in these markets.

Lay-up is hypothesized to depend on the profitability of the spot market relative to the costs in lay-up. This is because a laid-up ship forfeits the net revenues that it would earn on the high seas. Optimal behaviour implies that at the margin the cost in lay-up is equal to the cost of operating the vessel on the high seas. The latter depends on the level of freight rates, voyages costs and operating costs. This theory suggests that λ may be hypothesized as follows:

$$\lambda = F_2(\overset{-}{F}, \overset{+}{Pb}, \overset{+}{OC}, \overset{-}{LC}) \tag{3}$$

where

LC = Costs in lay-up

Thus supply is modelled in two stages. The first stage is equation (1). It captures the effect of increases in freight rates on the supply that arise through changes in optimum speed and possibly lower turnaround time in ports and generally more intensive utilization of the existing trading fleet. This equation treats lay-up and thus the trading fleet Kv as given and ignores the effects of freight rates on supply that arise through changes in the employment rate. This is modelled in a second stage which is equations (2), (3). To derive the market supply function, equations (2), (3) should be used to substitute for Kv in equation (1).

Demand

In theory demand should vary inversely with freight rates because higher freight rates will create an incentive to use other forms of transportation and to import more from areas closer to the market. In practise the scope for substitution and such economies is limited. Indeed, we have been unable to discover a negative relationship between demand and freight rates. Consequently, as in previous freight market models, demand will be considered to be completely inelastic with respect to freight rates and therefore it will be considered to be given at an exogenous level q.

Equilibrium

Freight rates respond rapidly enough to changes in market conditions and thus the freight market will be assumed to clear within the unit time period which in our case is a year. Thus supply always equals demand, hence:

$$q = q^{s} \tag{4}$$

where

q = Demand for dry cargo transportation services measured in ton-miles

Profits

The maximum profits generated by the ship when it runs at the optimum speed are related to prevailing freight rates, bunker prices and operating costs. This relationship was derived in section 3.3 equation 3.3.7 and is reprinted below as equation (5).

$$\pi_t = k(F_t^{1+\gamma})/(Pb_t^{\gamma}) - OC_t \tag{5}$$

The coefficient γ reflects the technological relationship between fuel consumption and speed and is equal to the price elasticity of freight market supply.

In the freight market we shall not distinguish dry cargo ships either by size or type or age because they are highly substitutable. Indeed the tramp freight rates of the various types are highly correlated as would be expected in a market where all ships provide similar services. These are the usual reasons for aggregation.

The dry cargo market largely consists of a highly competitive tramp market in which freight rates are highly flexible and responsive to changes in the underlying determinants of demand or supply. It also consists of a liner sector where rates are set by conferences and which are less responsive to demand or supply shifts. Data limitations prevent us from distinguishing between liners and tramps. This is likely to be of little consequence because typically ships can move from the one market to the other depending on the relative profitability and also because the liner market is relatively small. Because of the predominant role of the tramp market we estimate the model subject to a market clearing restriction (which turns out to be empirically acceptable).

4.2.2 Time Charter (Rental) Market

Equations (1), (2), (3), (4) determine the equilibrium freight rate in terms of the level of demand, the size of the fleet, fuel prices, combis in dry and other predetermined variables. This rate is a voyage or spot freight rate.

Shipowners can rent their ships out, under a time charter hire contract. The time charter contract is arranged between the shipowner and the 'charterer'. The charterer usually happens to be a shipper but it can be a speculator who hires out the ship with a view of either releting it for a higher rate or trading it in the spot market. In such cases the charter is in practise characterised as being a purely speculative time charter.

In reality time charters are always as much speculative whether the charterer is a shipper or not.

The time charter contract stipulates that over the duration of the contract control of the ship passes over to the charterer who is then entitled to the profits made out of its operation. For compensation the shipowner receives from the charterer a prearranged rent H per month known as the time charter rate. An important standard clause of the contract is that any voyage costs such as bunker costs, port charges or canal dues incurred during the duration of the contract will have to be paid by the charterer while all the operating (i.e fixed) costs are for owner's account. On the other hand when operating in the spot market the shipowner has to pay all the costs.

Speculation on time charters should ensure that the expected profitability of the spot market over the duration of the contract should equal the expected profitability derived from the alternative policy of arranging a time charter contract after allowing for a risk premium. Otherwise, if for example, the former were much higher than the latter there would be extreme speculative demand for charters that would raise time charter rates until equality was restored. If, on the other hand, the inequality happened to hold the other way round, there would be extreme speculative withdrawal of charterers from the market that would again tend to restore the equality.

Time charter contracts can be distinguished according to their duration. At one extreme there are very short term charters where the ship is rented for a few weeks while at the other extreme ships can be rented for more than 10 years. For a one year time charter, arranged at the end of time t, and which pays a time charter rate H_t, the expected profitability $E_t\pi'_{t+1}$ is

$$E_t\pi'_{t+1} = H_t - E_tOC_{t+1} \qquad (5')$$

where the inclusion of the E_tOC_{t+1} term reflects the fact that even when the ship is on hire the owner still has to pay for the fixed operating costs incurred. Therefore the expected profitability is simply the difference between the guaranteed fixed time charter rate and the expected operating costs which as already mentioned are for owner's account.

On the other hand the profitability of the voyage market depends on the spot rate, voyage costs and operating costs as in (5). Thus the expected profitability $E_t\pi_{t+1}$ of the alternative strategy of operating on the spot market is given by leading equation (5) once and taking expectations at time t which gives

$$E_t\pi_{t+1} = E_t(F_{t+1}^{1+\gamma}/Pb_{t+1}^{\gamma}) - E_tOC_{t+1} \qquad (5'')$$

According to the theory the expected profitability $E_t\pi'_{t+1}$ of the time charter contract as given by expression (5') should equal the expected profitability $E_t\pi_{t+1}$ in the spot market over the duration of the contract as given by (5''). Thus equating the right hand side of equation (5') with that of (5'') and taking into account a risk premium μ gives

$$H_t = \mu E_t(F_{t+1}^{1+\gamma}/Pb_{t+1}^{\gamma})$$

which in logarithms can be written as

$$lnH_t = (1+\gamma)E_t lnF_{t+1} - \gamma E_t lnPb_{t+1} + \mu \qquad (6)$$

The time charter market is completely peripheral to the rest of the model. A time charter contract between a shipowner and a shipper reduces the spot supply exactly by the same amount as the spot demand leaving the equilibrium spot rate unaffected. Time charters are simply instruments for passing on the entitlement to spot market profits over the contract duration to another investor. The underlying determinants of spot market rates are thus not affected. They are considered here, both for reasons of completeness (a lot of business is undertaken on a time charter basis) but mainly because it simplifies certain econometric estimation problems. The next section shows that expected profits affect the portfolio demand for ships. The time charter rate can provide us with an accurate market index of, otherwise unobservable, expected profits (before fixed costs) as equation (5') suggests.

4.2.3 Second Hand Market

Ships are capital assets and the portfolio demand for ships should depend on their relative return i.e.

$$(P_t K_t^d / W_t) = F_3(\overset{+}{E_t \pi_{t+1}/P_t}, \overset{+}{E_t P_{t+1}/P_t}, \overset{-}{r_t})$$

where all variables and expectations are taken at the end of the year. Ship prices and the fleet are end of the year values while π_{t+1} denotes the accumulated profits over the whole year. The above equation can be solved for P_t and this implies

$$P_t = F_4(\overset{+}{W_t/K_t}, \overset{+}{E_t \pi_{t+1}}, \overset{+}{E_t P_{t+1}}, \overset{-}{r_t}) , \qquad (7)$$

When expected profits or future prices increase this raises the expected return on ships. There is then a tendency for capital to flow into shipping and this raises the values of ships and brings the return down until the excess demand is eliminated. The opposite happens when the return on other assets increases. An increase in the size of the fleet implies that in equilibrium investors should hold a portfolio which is more heavily weighted towards ships. This loss of diversification increases risk which requires a reduction in prices. On the other hand some of the increase in demand for assets associated with an overall increase in wealth is likely to spill over into ships and this increases prices.

4.2.4 Shipbuilding Market

The supply of new ships is hypothesized to depend on the ratio of newbuilding prices to shipbuilding costs as suggested in chapter 3. Modelling the shipbuilding market introduces two new complications. One arises from the fact that shipbuilders can build other ship types in addition to dry cargo vessels. The other arises from the fact that the time between ordering and delivery is not constant as the simple model of chapter 3 assumed, but varies with market conditions.

Joint production of dry cargo and tanker newbuildings

The first complication reflects the jointness of the production process. Shipyards' resources can be employed not only in the construction of new dry cargo ships but also in the construction of tankers. The theory of the firm in the case of joint products is relevant here. This suggests that the supply of new dry cargo ships depends positively on dry cargo newbuildings' prices and negatively on the prices of shipbuilding costs, as was also the case in chapter 3. In addition, however, the supply of dry cargo newbuildings will be also affected by the profitability of building tankers. If prices of tankers increase, shipyards will tend to divert resources towards the construction of tankers which would adversely affect dry cargo newbuilding. Thus, in addition, supply of new dry cargo ships depends negatively on the price of the alternative tanker product.

The order book

We use the order-book to represent the intended supply of new ships. The second complication reflects the fact that the time between ordering and delivery and thus the length of the order-book, varies. The size of the order-book can be thought of as the product of two factors. The first is the length of the order book which is the length of time over which current orders are planned to be depleted from the book. The second factor is the rate at which shipyards intend to deliver ships from the order-book. Obviously the theory developed in the previous chapter pertains to this second factor while no consideration has yet been given to the factors that determine the length of the order-book. This would not matter at all in a perfect foresight enviroment. The theory developed in chapter 3, would suffice in this case, to explain the fluctuations in deliveries while the length of the order-book could be ignored. However in an uncertain environment and where cancellation of an order is very expensive for the investor, the length of the order-book would matter in those cases where there are major unanticipated changes in the values of ships.

Theoretically the length of the order-book depends upon the various risk premia that investors require in order to sign orders and also on attitudes of the shipbuilder towards risk. Uncertainty increases with the time horizon and thus these risk premia are likely to increase as the time of promised delivery is extended further into the future. This will set an upper bound to the period of time over which shipyards and investors will come to terms. The theory suggests that apart from unobservable attitudes to risk the length of the order-book will vary with newbuilding prices. When prices are strong, builders can offer large discounts needed for attracting orders for distant deliveries and still leave room for profit. When however prices are weak it will be difficult for builders to offer heavy discounts and at the same time leave room for profit. Thus in the latter case owners and yards will be able to come to terms only for deliveries in the immediate future and so the length of the order-book will contract. This theory thus implies that the length of the order-book depends on exactly the same factors that affect the delivery rate as analysed in chapter 3. Thus this complication does not, after all, require any modifications of the econometric specification.

Our proposed specification for the order-book which reflects our theoretical views pertaining to the first and second factor, that is the length of the order book and the delivery rate, is the following:

$$Q = F_5(\overset{+}{Pn}, \overset{-}{Pn'}, \overset{-}{P1}, \overset{+}{P1'}; Z_Q) \tag{8}$$

where

Pn = Newbuilding prices of dry cargo ships

Pn' = Newbuilding prices of tankers

$P1$ = Dry cargo shipbuilding cost index

$P1'$ = Tanker shipbuilding cost index

Z_Q = Other variables that might influence Q

Thus we have included newbuilding prices and costs of shipbuilding inputs as determining factors. The effect of own prices reflects two phenomena. First higher prices tend to increase the planned delivery rate and second they are positively related to the length of the order-book. In addition the prices and costs of building tankers have been included because typically shipbuilders can also build tankers and they will increase their supply of new tankers (at the expense of dry cargo newbuildings) if they find it more profitable as explained above. This is one of the ways in which the tanker market can influence the dry cargo market.

The estimated equation is a dynamic version of equation (8) where the lags have been determined empirically. Deliveries are hypothesized to be a function of lagged orders.

$$D_t = \sum_{i=1}^{m} w_i Q_{t-i} \tag{9}$$

This reflects the fact that a ship once on the order-book will very rarely not be delivered since cancellations are costly for the investor especially if construction has already begun. The positive effect of prices on deliveries is already embodied in the order-book equation.

Newbuilding prices

The theory suggests that newbuilding prices reflect the expectations at the time of ordering regarding the second hand values at the time of delivery. Assuming that on average there is a one year lag between order and delivery this implies

$$Pn_t = E_t P_{t+1} + k \tag{10}$$

where

k = risk premium on newbuildings

4.2.5 Scrap market

As in the previous chapter it is assumed here that scrapping is affected by the level of second hand prices relative to the price of scrap which is treated as exogenous. In chapter 6 where the dry cargo and tanker models are linked, the price of scrap is endogenised. In chapter 3 no account was taken of the likely influence of the age profile on aggregate scrapping. The scrapping rate should be higher among older ships than among younger ones. Thus when the average age of the fleet increases scrapping should also increase. During the post World War II period there have been significant changes in the age profile of the fleet which has considerably influenced the overall scrapping rate. It was therefore considered desirable to disaggregate dry cargo ships by age in the scrap market. Thus 5 age groups have been distinguished and accordingly individual scrapping supply equations have been estimated for each age group. The 5 age groups are 0-5 year old, 5-10, 10-15, 15-20 and 20 years and over. In light of the empirical evidence we have assumed that there is always zero scrapping within the first two age groups. For the remaining age groups it has been assumed that scrapping varies inversely with the ratio of second hand values to scrap values. Thus we have

$$s_i = F_8^i(\bar{P}/P_s) \qquad i = 3,4,5 \tag{11}$$

$$s_i = 0 \qquad i = 1,2 \tag{11'}$$

where the five age groups have been indexed by i = $1,2,3,4,5$. For example, $i=1$ stands for age group 0-5, $i=3$ stands for age group 10-15 and $i=5$ stands for the age group of over 20 year old ships. Thus s_i represents the scrapping rate in age group i. The aggregate scrapping rate is a weighted average of the individual scrapping rates within each age group where the weights are the proportion of ships within each age group. Hence:

$$s = A_3 s_3 + A_4 s_4 + A_5 s_5 \tag{12}$$

where

s = Aggregate scrapping rate

A_i = proportion of ships in age group i

Total scrapping is then given by

$$S = Ks \tag{13}$$

4.2.6 Age Profile

The age profile of the fleet is obviously endogenous and historically there have been significant fluctuations in it. The dynamic evolution of the age profile is identically determined from sufficiently detailed knowledge of the age distribution and the annual scrappings of ships of various ages. If for simplicity we assume that the age distribution of the fleet within subdivisions of a particular age group was uniform and, in addition, the scrapping rate was constant within these subdivisions, then the dynamic evolution of the fleet would be given by the following identities

$$A_{i,t}K_t \equiv$$
$$A_{i-1,t-5}K_{t-5}\left(1 - (1/2)\sum_{j=1}^{5} s_{i,t-j} - (1/2)\sum_{j=1}^{5} s_{i-1,t-j}\right) \qquad (14)$$

for $i = 3,4,5$

and since there is zero scrapping in the first two age groups the above simplifies to:

$$A_{i,t}K_t \equiv A_{i-1,t-5}K_{t-5} \qquad (14')$$

for $i = 2$, and

$$A_{i,t}K_t = \sum_{j=0}^{4} D_{t-j} \qquad (14'')$$

for age group i

In other words equation (14) says that the number of ships in age group i at time t is equal to the number of ships in age group $i-1$ 5 years ago minus the number of ships that have been scrapped. Equation (14′) is similar to equation (14) but here there is no need to allow for ships scrapped since there is no scrapping in the first two age groups. Equation (14′′) determines the amount of ships in age group 1 and these are simply the total number of ships that have been delivered from the yards in the last five years.

Equations (14) which refer to age groups 3, 4, and 5 have been derived theoretically based on the assumption that the fleet is distributed uniformly within age subdivisions of a particular age group plus the assumption that the scrapping rate is identical within those subdivisions. Obviously both assumptions are not strictly true although this should not matter greatly. There is little that can be done to correct for the first assumption short of collecting information regarding the distribution of the fleet and scrapping within subdivisions of the age group. This information is not available. But we can easily correct for the second assumption. It is obvious that scrapping should be lower within the younger subdivisions of our age groups. This suggests that the scrapping rate of the younger age group in equation (14) should be given relatively more weight than the scrapping rate in the next age group. Thus our chosen specification for the dynamic evolution of the fleet in age groups *3, 4, 5* is

$$A_{i,t}K_t = A_{i-1,t-5}K_{t-5}\left(1 - (3/10)\sum_{j=1}^{5} s_{i,t-j} - (7/10)\sum_{j=1}^{5} s_{i-1,t-j}\right) \tag{14'''}$$

The weights have been chosen so as to give the best fit over the historical period. Indeed they give an excellent fit as should be expected from an equation that is almost an identity.

Evolution of the fleet

Finally the size of the fleet at the end of year t is given by the size of the fleet in the previous year plus the new deliveries minus the ships scrapped within the year. Thus

$$K_t = K_{t-1} + D_{t-1} + S_{t-1} \tag{15}$$

Equations (1) - (15) solve dynamically for q^S, F, K_v, λ, π, H, P, P_n, Q, D, s_i, s, S, A_i, K in terms of q, P_b, OC, LC, p_c, K_c, Z_q, W, r, P_n', P_l, P_l', Z_Q, P_s.

4.3 Estimation

The model consists of equations (1)-(15) and these are listed in Table 4.1. Equations (2), (4), (12), (13), (14) and (15) are either identities or equilibrium conditions which involve no unknown parameters.

Data on actual profits π_t are not available. Thus equation (5) cannot be estimated. Equation (7) also involves a term in expected profits and cannot be estimated as it is. Profits do not appear in any other parts of the system. To solve this problem we could substitute out the profit term in (7) by its determinants as given by the RHS of equation (5). Even better, we can use relationship (5') to substitute directly the expected profit term in terms of the time charter rate and expected operating costs. This is valid since, as already explained, the expected profitability of any chartering policy (spot or time charter) should be equal. This substitution implies:

$$P_t = F_4(W_t/K_t, H_t - E_tOC_{t+1}, E_tP_{t+1}, r_t) \qquad (7')$$

Thus the actual system to be estimated consists of equations (1)-(15) except for equation (5) which has been omitted and equation (7) which has been replaced by equation (7').

4.3.1 Econometric methodology

Our approach to estimating the model's unknown parameters is purely econometric. That is, the coefficients of the model are estimated from the empirical data taking into account various theoretical cross equation restrictions but without making use of any other prior information regarding the likely values of the unknown parameters. This is, of course, quite standard, however it contrasts with non-econometric modelling in shipping e.g. the Nortank and Martinet models that were analysed in chapter 2. In many cases estimates were based on a priori information rather than the data. For example, the freight market supply function was often derived from knowledge of the technology of the ships i.e the production function. Each approach has its advantages and disadvantages. The approach adopted here has the disadvantage of ignoring any prior information. However such information is usually vessel-specific. A priorism has therefore only been utilized in disaggregated models. These have been limited to modelling freight market movements since disaggregation has been an obstacle to integrating the freight market with the ship markets.

In our aggregated model it is not appropriate to adopt a representative ship type because of the variance in size, age, technology etc. among the various types. On the other hand the aggregate econometric approach has the advantage that it is relatively easy to integrate not only the freight market and the ship markets but also the various major sectors such as tankers and dry cargo.

Data for the post World War II period are used in order to estimate the simultaneous relationships described in the previous chapter. The estimation methods chosen reflect a balance between, on the one hand, the desirability of increasing the efficiency of estimation and on the other the computational costs that this incures. Efficiency requires that the econometric methods chosen should reflect simultaneity, expectations generating mechanisms as well as any coefficient restrictions. Estimation can be simplified without sacrificing efficiency by taking into account the block recursiveness of the system. Still, the most efficient method would be computationally very demanding. Single equation methods have therefore been utilized in addition to system estimation procedures.

Equations (6), (7) and (10) involve unobserved 'rational expectations' of endogenous variables. Equations involving 'rational expectations' can pose estimation problems that are not always encountered in other cases. This is because observations on expectations are not normally available. There are various ways of estimating equations involving rational expectations see e.g. Wallis (1980) and Wickens (1982). One way that eliminates all the peculiar problems is to use exact measurements of the rational expectations variables. In this case the R.E. variables can be treated as any other variable in the equation and the standard estimation procedures can be applied. This method is the most desirable since it allows the coefficients to be estimated with maximum efficiency. Unfortunately it is least likely to be feasible since, as already indicated, it requires observations of the market's expectations which are rarely available.

Another method is the "substitution method" see e.g. Wallis (1980). The model is used to generate forecasts of the rational expectation variables. These forecasts are complicated functions of the models' parameters, the parameters of the stochastic processes that describe the evolution of the exogenous variables and the information set on which expectations are conditioned. The stochastic processes of the exogenous variables have to be specified. They are usually modelled as vector autoregressive moving average process. The VARMA process is augmented to include all variables that are relevant for forecasting the future level of the exogenous variables.

The VARMA process is incorporated to the main model and the whole system is solved by maximimising the likelihood function with respect to the unknown parameters of the model. This provides efficient estimates but the method is unlikely to be robust. Misspecifications will in general lead to biased estimates for all the system's coefficients. In addition the method is computationally demanding. It also involves the specification and estimation of an auxiliary model that describes the evolution of the exogenous variables. This increases the chances of misspecification. In our case the substitution method would require specifying models for world trade, oil prices, interest rates, prices of metals etc. in addition to the factors that are relevant for predicting these variables. Matters are complicated by the structural break that occured in 1973/1974 with the advent of OPEC and the effect of its policies on not only oil prices but also trade, inflation, world interest rates, commodity prices etc.

Another method for estimating equations with rational expectations and which is computationally much simpler is the "errors in variables" method, see e.g. Wickens (1982). This simply replaces the expectation with the actual realised value for the variable. This introduces an errors in variables problem since in an uncertain environment the actual value will differ from the expected one by a random forecasting error. This measurement problem can be handled with standard instrumental variables methods. The instruments used are a subset of the information set which are relevant for predicting the future value of the variable. This method gives consistent estimates since the measurement (forecast) error is uncorrelated with these instruments by construction. In addition this method is more robust wee e.g. West (1986), but not as efficient as the substitution method in cases, such as ours, where expectations of future endogenous variables are involved.

Freight Market Block

Equations (1)-(6) constitute the freight market block. This set of equations is block recursive with respect to the ship markets' block which consists of equations (7)-(15). This is because the fleet size which affects the supply of freight is predetermined by past events in the scrapping and shipbuilding market. In addition there are no cross equation restrictions between the freight market and the ship markets block so the freight market block can be estimated separately without loss of efficiency. The block to be estimated consists of the following equations

$$q = F_1(\ (1-\lambda)K+p_c Kc,\ F/Pb,\ Z_q) \tag{1'}$$

$$\lambda = F_2(\ F,\ Pb,\ OC,\ LC) \tag{3}$$

$$lnH_t = (1+\gamma)E_t lnF_{t+1} + \gamma E_t lnPb_{t+1} + \mu \tag{6}$$

where (1′) has been derived by using the identities (2) and (4) in order to substitute for q^s and Kv in (1). As already mentioned equation (5) has been taken out of the system. Equations (1′), (3) and (6) are estimated jointly by 3SLS. There is no simultaneous interaction between equation (6) and the remaining part of the freight market block. However as was shown in chapter 3 the coefficient γ in (6) must equal the elasticity of freight market supply in (1′). Thus efficiency requires that these equations should be estimated jointly with the coefficient restriction imposed.

Equations (1′) and (3) jointly determine the equilibrium level of freight rates and lay-up in terms of the predetermined variables which include the level of demand q, the size of the fleet K, bunker prices Pb etc. The latter are used as instruments in the 3SLS procedure. Equation (6) involves unobservable expectations of freight rates and bunker prices. The expectations are substituted by their actual forward values and the disturbance term of the equation is redefined to include the forecast error of rates and bunker prices. The forward values should be instrumented by a subset of the current information set which is relevant for predicting rates and fuel prices. Conveniently, the variables already used for instrumenting current freight rates and lay-up are the relevant ones for predicting rates and fuel prices. In addition lagged demand and the current order book has been included in the instrument list.

Ship Markets Block

The ship markets block consists of equations (7)-(15). These are estimated by single equation methods.

Equation (7) involves expectations of two endogenous variables. These are significantly correlated and thus difficult to instrument separately given the unpredictability and volatility of the shipping markets. Fortunately direct observations on these expectations can be found. In (7′) the time charter rate minus operating costs has already been used to substitute for expected profits. As equation (10) suggests the observable newbuilding price reflects expected future second hand prices and it can therefore be used as an index of these expectations. Using (10) to substitute for $E_t P_{t+1}$ in terms of the observable newbuilding price gives

$$P_t = F_4(W_t/K_t, H_t - E_t OC_{t+1}, Pn_t, r_t) \qquad (7'')$$

Strictly speaking there is an "errors in variables" problem here too. This is because of the appearance of the term $E_t OC_{t+1}$ in (7′′). However this term can easily be instrumented since OC is basically a trending variable. The other variables do not have to be instrumented. Consequently, this is almost equivalent to performing OLS given the accuracy with which expectations are observed and the fact that expected operating costs can be easily instrumented.

We began with the original equation (7) which presented an awkward estimation problem due to the appearance of the two unobservable, volatile and highly correlated expected profit and price terms that were very difficult to instrument separately. Fortunately, by using other relationships in the model, we were able to transform this into equation (7′′) which can be estimated by a procedure almost equivalent to carrying out OLS on (7) with exact measurements on the expectation terms. The efficiency of the latter is much higher than carrying out an "errors in variables" instrumental procedure on (7) which indeed gave very poor results.

Alternative estimation methods of (7′′) were tried. As already mentioned the selected procedure only uses instruments for the expected operating cost term while the endogenous time charter and newbuilding price terms are not instrumented. Alternative procedures in which the endogenous time charter and newbuilding price terms were instrumented gave very similar results. This is because the link between the disturbance terms and these endogenous expectation variables is weak. In turn this is due to the fact that these endogenous terms reflect expectations of *future* variables the forward values of which are only to a small extent affected by the *current* disturbance term. Moreover, significant exogenous shocks over the sample period reduced the proportion of the variance of endogenous movements attributed to the disturbance term. This reduces the bias and the variance of our procedure. It might even render it preferable to the alternative procedure of instrumenting the expectation measurements, since it might be desirable to trade off some bias for the reduced variance of our chosen estimation method.

Equation (10) involves only an unknown constant which reflects a risk premium on newbuildings and the depreciation factor on second hand ships. In addition because our data for newbuilding prices and second hand values are indepedently based indices, the constant in this case should reflect the arbitrary basing of the indices. A change in the base will introduce an arbitrary change in the constant. Thus the estimated constant does not have any economic interpretation. The actual future second hand price will deviate from its expected value by a random forecast error $u_t = P_{t+1} - E_t P_{t+1}$ which is uncorellated with any current information and in particular with Pn_t when expectations are rational. Thus equation (10) can be written as

$$P_{t+1} = - k + Pn_t + u_t \qquad (12')$$

and because of the correlation properties of u_t, the nuisance constant k can now be efficiently estimated by OLS.

The scrapping equations (11) are also estimated by

OLS. This theoretically will introduce some bias since second hand values and scrapping are jointly determined. An instrumental variables method has also been used and has given very similar results. The bias of the OLS estimates is likely to be so small as to make it more reliable than a two stage least squares estimation procedure in a small sample such as ours. The variance of the latter is higher and depends on the quality of the instruments. The bias of the OLS estimates arises from the fact that the error term in the scrapping equation might be correlated with second hand values which is one of the regressors. The size of the bias depends on the extent to which fluctuations in ship values over our sample period are attributed to the error term in comparison with those that are attributed to exogenous influences. The effect of the disturbance term of an individual scrapping equation on the general level of ship values is likely to be so small as to be dwarfed by the effect of exogenous factors, especially since scrapping within an age class constitutes a very small proportion of the total fleet.

Equations (8), (9) have also been estimated by OLS. This is because equation (9) involves only predetermined lagged endogenous variables on the right hand side. Thus OLS is expected to give efficient estimates as long as the error term is not autocorrellated. In equation (8) there is likely to be some correlation between the error term and newbuilding prices. This however is expected to be quite small for the same reasons as for the scrapping and asset demand equations. Newbuilding prices reflect future profitability and not the current disturbance. Two stage least squares gave similar results.

A model should explain the systematic movements in the data, so that what remains i.e the residual should be random. If residuals are autocorrellated this may indicate misspecification such as the exclusion of an important variable or dynamic misspecification. The presence of autocorrellation reduces the efficiency of the chosen estimation procedures and may induce bias and inconsistency in the estimates of the parameters, the standard errors and the test statistics. We test for autocorellation by computing the first four sample autocorellations of the residuals and the associated Box-Ljung statistics. The latter are portmanteau statistics calculated as a weighted average over the correlogram of the residual, with weights chosen so as to give a better approximation to the asymptotic χ^2 distribution in small samples such as ours.

4.3.2 Results

The econometric estimates of the behavioural equations of the model are presented in Table 4.2. To assist comprehension the estimated equations have been numbered in the same way as the corresponding theoretical ones. Thus equation $(\hat{1})$ corresponds to the estimate of equation (1) and so on.

Equation (1) has been solved for F after taking q to the right hand side and the transformed inverted supply equation has been estimated jointly with equations (3), and (7) to take account of cross equation restrictions and simultaneity. Equation (1) captures the effect of an increase in freight rates on the supply that arises through more intensive utilisation of the trading fleet while keeping lay-up fixed. It becomes the supply function only when lay-up hits zero and therefore cannot be reduced any more. Thus equation $(\hat{1})$ indicates that when lay-up is close to zero a 10% increase in the freight market balance will increase freight rates by 42.2%. The coefficient 4.22 multiplying the freight market balance term $q - K$ in $(\hat{1})$ is the inverse of γ. It implies a value for γ equal to 0.24 which is the estimated elasticity of supply at very small levels of lay-up. At low levels of lay-up however the elasticity of supply can become much higher as an increase in rates will significantly increase the employment rate in addition to the utilisation rate of the trading fleet.

Table 4.2 Econometric Estimates[1]

Freight Market & Time Charter Rates

3SLS 1962 - 1985

$$lnF = \underset{(12.8)}{6.05} + \underset{(9.47)}{4.22}(lnq^{S} - lnKv) + lnPb - \underset{(-19.2)}{6.60}lnLH \qquad (\hat{1})$$

$\bar{R}^2 = 0.956$, $S.E = 0.134$, $D.W = 2.05$

$AR_1 = -0.049$, $AR_2 = -0.204$, $AR_3 = 0.069$, $AR_4 = -0.153$

$BL(2) = 1.24$, $BL(4) = 2.12$

$$ln(\lambda/(1-\lambda))$$
$$= \underset{(2.47)}{16.36} + \underset{(2.47)}{0.30}ln(\lambda/(1-\lambda))_{-1} - \underset{(-7.15)}{3.04}ln(F/(Pb+OC))$$
$$- \underset{(-2.59)}{1.38}ln(F/(Pb+OC))_{-1} - \underset{(-6.96)}{7.89}lnAS \qquad (\hat{3})$$

$\bar{R}^2 = 0.871$, $S.E = 0.360$, $D.W = 1.85$

$AR_1 = 0.060$, $AR_2 = -0.164$, $AR_3 = 0.026$, $AR_4 = -0.092$

$BL(2) = 0.86$, $BL(4) = 1.14$

$$lnH_t = \underset{(-2.75)}{-\ 0.17} + 1.24E_t lnF_{t+1} - 0.24E_t lnPb_{t+1} \qquad (\hat{6})$$

$\bar{R}^2 = 0.723$, $S.E = 0.323$, $D.W = 1.60$

$AR_1 = 0.106$, $AR_2 = -0.168$, $AR_3 = 0.112$, $AR_4 = 0.089$

$BL(2) = 1.11$, $BL(4) = 1.73$

[1] Figures in parentheses are t-statistics for testing the null hypothesis that the true value of the coefficient is zero. AR(j) is the autocorrelation of the residuals at lag j and BL(j) is the Box-Ljung statistic which takes account of the residual autocorrelation up to and including lag j.

Second Hand Market

Instrumental Variables 1960 - 1985

$$\ln P_t = -0.54 + 0.09\ln(W_t/K_t)$$
$$\quad (-2.92) \quad (1.98)$$

$$+ 0.27\ln((H_t - E_tOC_{t+1})/(1 + r_t)) + 0.73\ln(Pn_t/(1+r_t))$$
$$(5.87) \qquad\qquad\qquad\qquad (15.87) \qquad (\hat{7})$$

$\bar{R}^2 = 0.975,\ S.E = 0.082,\ D.W = 1.77$

$AR_1 = -0.043,\ AR_2 = -0.277,\ AR_3 = 0.137,\ AR_4 = 0.096$

$BL(2) = 2.38,\ BL(4) = 3.29$

Scrapping

OLS 1960 - 1985

$$ln(s_3/(1-s_3)) = -\ 8.91 - 2.35ln(P/P*) - 2.77DUMs_3 \qquad (\hat{11})$$
$$\qquad (-17.08)\ (-4.02) \qquad (-4.38)$$

$\bar{R}^2$ = 0.632, S.E = 0.616, D.W = 2.33

AR_1 = -0.255, AR_2 = 0.228, AR_3 = 0.165, AR_4 = -0.170

BL(2) = 3.48, BL(4) = 5.30

$$ln(s_4/(1-s_4)) = -\ 2.84 + 0.61ln(s_4/(1-s_4))_{-1}$$
$$\qquad (-3.18)\ (4.43)$$
$$-\ 1.37ln(P/P*) - 1.71DUMs_4$$
$$(-2.58) \qquad (-3.18)$$

$\bar{R}^2$ = 0.660, S.E = 0.519, D.W = 1.77

AR_1 = 0.077, AR_2 = -0.201, AR_3 = 0.040, AR_4 = -0.309

BL(2) = 1.39, BL(4) = 4.60

$$ln(s_5/(1-s_5)) = -\ 1.06 + 0.80ln(s_5/(1-s_5))_{-1}$$
$$\qquad (-2.44)\ (5.29)$$
$$-\ 0.67ln(P/P*)$$
$$(-2.01)$$

$\bar{R}^2$ = 0.521, S.E = 0.347, D.W = 1.73

AR_1 = 0.127, AR_2 = 0.139, AR_3 = -0.199, AR_4 = -0.017

BL(2) = 1.05, BL(4) = 2.31

Shipbuilding

OLS 1952 - 1986

$$\underset{}{lnQ_t} = \underset{(1.52)}{0.70} + \underset{(3.29)}{0.80 lnQ_{t-1}} - \underset{(-2.01)}{0.55 lnD_{t-1}} + \underset{(3.51)}{0.54 ln(Pn_t/Pi_t)}$$

$$- \underset{(-1.04)}{0.12 ln(Pn'_t/Pi'_t)} + \underset{(2.66)}{0.51 lnCP_{t-1}} \qquad (\hat{8})$$

$\bar{R}^2 = 0.891$, $S.E = 0.177$, $D.W = 1.51$
$AR_1 = 0.217$, $AR_2 = -0.135$, $AR_3 = -0.173$, $AR_4 = 0.046$
$BL(2) = 2.50$, $BL(4) = 3.80$

$$lnD_t = - \underset{(-4.26)}{0.61} + \underset{(4.32)}{0.34 lnD_{t-1}} + \underset{(8.24)}{0.59 lnQ_{t-1}} - \underset{(-2.59)}{0.06 lnQ'_{t-1}}$$

$$+ \underset{(1.85)}{0.20 lnCP_t} \qquad (\hat{9})$$

$\bar{R}^2 = 0.973$, $S.E = 0.096$, $D.W = 1.41$
$AR_1 = 0.264$, $AR_2 = -0.023$, $AR_3 = -0.078$, $AR_4 = -0.010$
$BL(2) = 2.67$, $BL(4) = 2.91$

Newbuilding Prices

OLS 1960 - 1985

$$lnP_{t+1} = - \underset{(-2.57)}{0.18} + lnPn_t \qquad (\hat{10})$$

$\bar{R}^2 = 0.517$, $S.E = 0.356$, $D.W = 1.25$
$AR_1 = 0.374$, $AR_2 = -0.180$, $AR_3 = -0.125$, $AR_4 = -0.005$
$BL(2) = 5.06$, $BL(4) = 5.55$

Our estimate of γ is not significantly different from that reported by Tinbergen (1934), Koopmans (1939) and Wergeland (1981).

The average length of haul (*LH*) was specified in equation $(\hat{1})$ as an additional exogenous variable affecting the utilization of the trading fleet. The reason for this is that when ships undertake longer voyages then the proportion of unproductive time spent in port falls, which increases supply. Its effect on supply can be estimated by dividing the coefficient of *LH* by minus the coefficient of q^{*}. This implies a 1.56 elasticity of supply with respect to *LH* which is positive as expected.

The estimated lay-up equation $(\hat{3})$ is dynamic and reflects the significant costs in moving ships in and out of lay-up. Theoretically such costs will introduce dynamic complications in the response of lay-up to freight rates and costs. It can be seen from $(\hat{3})$ that the long run response of employment to changes in market conditions is stronger than the response in the short run. The average size of ships (*AS*) was also specified to affect the lay-up rate. This is because large ships are more efficient and can profitably trade at rates which are uneconomic for the smaller ones. Thus an increase in size is expected to reduce lay-up at given freight rates. The econometric estimates indeed suggest that lay-up is inversely related to size.

The time charter rate equation has been estimated jointly with the freight market equations to reflect cross equation restrictions. The coefficient on expected freight rates is constrained to equal $1+\gamma$ which is equal to 1.24 while the coefficient on unit voyage costs is $-\gamma$, that is, -0.24. It indicates that at low levels of lay-up a 10% improvement of the freight market balance will increase profitability before fixed costs by 52%.

The regressions of the freight market block are characterised by high $\bar{R}^2$s. The relatively lower figure for the time charter rate equation is not indicative of the validity and the explanatory power of the equation.

This is because this equation contains unobservable expectations of volatile and unpredictable freight rates and fuel prices. Thus a low $\bar{R}^2$ reflects the fact that the unobservable expectations cannot be proxied accurately. Had accurate measurements on expectations been available the $\bar{R}^2$ could have been much higher.

Equation $(\hat{7})$ is the empirical version of equation (7). It relates the equilibrium second hand price to expected one year profitability, expected second hand prices, alternative returns and a risk premium that varies with the size of the fleet in relation to investors' wealth. Since ships are assets with an economic lifetime that can extend over 20 years it should be expected that the elasticity of prices with respect to expected short term profits should be much smaller than the long term profitability elasticity. The latter is incorporated in the expected future second hand term. Indeed the coefficient on the expected short term profitability is 0.27 while the estimated coefficient of the expected future price is 0.73. Thus, a short term, 10% increase in expected one year profitability leads to a 2.7% increase in prices while a 10% increase in long term profitability and thus future second hand values leads to a speculative increase in current prices of 7.3%. This is in order to eliminate the possibility of excessive anticipated capital gains. The sum of the two coefficients has been constrained to equal to 1 so that a permanent 10% increase in profits leads to a 10% increase in prices. The unconstrained regression gave very similar results and did not reject the constraint.

In spite of the high volatility of ship prices, the estimated inverted asset demand equation $(\hat{7})$ is characterised by a very high $\bar{R}^2$ and a low standard error. These are indicative of the very satisfactory goodness of fit. In addition the estimated coefficients are consistent with a priori views[2]. Thus, we might say, that the empirical results give strong support to our capital asset approach.

Considering the difficulties and poor results - which are mainly due to the problem of unobservable expectations - that are normally encountered in the estimation of asset demand functions, these satisfactory results are pleasantly surprising. In turn this largely reflect the fact that we were able to find accurate measurements of otherwise unobservable expectations allowing the equation to be estimated with maximum efficiency.

Equations $(\hat{11})$ are the estimated scrapping supply equations. The results are similar for all three equations and they indicate that ship prices relative to scrap values have a negative effect on scrapping in all age classes. As expected, scrapping increases as we move to older age groups. This is indicated in the three scrapping equations by the fact that the size of the constant of the regression divided by the sum of the coefficients of the lag polynomial of the dependent variable increases as we move down the estimated equations. They indicate that if the ratio of ship prices and scrap values were to stabilize at its historical average then the long run scrapping rate in the age class over 20 years old would be around 8%, that of the 15-20 years old ships would be 1.2% while that of the 10-15 years old would only be 0.2%. It can be seen that the scrapping rate in the younger age groups becomes less significant. However during depressions when ship values

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[2] The low t-statistic on the wealth variable is not surprising. This coefficient is actually expected to be a small number and indeed its theoretical value is zero in the case of risk neutrality. Naturally, given our small sample size, the effect of wealth cannot be easily discerned in the data.

fall by more than scrap prices, the scrapping rate in the younger age groups can increase significantly.

Equation $(\hat{8})$ is the empirical version of equation (8). It shows that an increase in prices of new dry cargo ships has a positive impact on the order-book. The long run elasticity of the order-book with respect to prices after taking into account the long run effect of orders on deliveries and the feedback to orders is 0.77. This does not represent the long run increase in the supply of new ships since part of the increase in the order-book reflects the lengthening effect of prices on orders. Tanker prices are shown to have a negative effect on dry cargo orders but this is not statistically significant. The term *CP* is a measurement of shipbuilding capacity. Theoretically it is expected that an increase in capacity should have a positive effect on the supply of orders. Equation $(\hat{11})$ estimates the lagged response of deliveries to orders. The long run effect of a 10% increase in the order-book is to increase deliveries by 9.2%. This is because part of the increase in the order-book reflects the lengthening process and not an intended increase in the supply of new ships per year. The tanker order-book is estimated to have a negative impact on dry cargo deliveries as it diverts capacity towards tanker construction.

Equation $(\hat{10})$ is the relationship between newbuilding prices and expected future second hand prices. The two are equal up to a constant which in our case does not only reflect risk premia on newbuildings but also the arbitrary basing of the two indices. Thus the estimated constant has no economic interpretation.

Overall the empirical estimates conform to our a priori views regarding their signs. The diagnostic statistics which test for autocorrelation in the residuals are also reported in Table 4.2 underneath each equation. All the Box Ljung statistics are insignificant although in a very few case this is marginally so. All the estimated autocorellations are also insignificant at the 5% level except the AR_1 value for equation $(\hat{10})$.

This is one significant autocorrelation out of the 40 estimated ones which can easily be due to random sampling. Thus these tests do not cast any significant doubts on our specification although it is still possible that there are inconsistencies that these tests have not been able to detect.

4.4 Simulations

In chapter 3 the properties of the theoretical model were investigated by subjecting it to various anticipated and unanticipated shocks. By using the phase diagram the time pattern of the market's response to a change in the external environment was derived. Here the same simulations are performed using the estimated econometric model of the dry cargo market. Since the econometric model is based on the same theory, the qualitative features of the simulations carried out here are broadly similar to those investigated in chapter 3. In addition, however, the simulations considered here can determine the order of magnitude of the response as well. The results reflect the estimated elasticities of the model. If the system is elastic in the sense that the price elasticities of the freight market, newbuilding and scrapping supply/demand functions are high, then there should be little change in the time path of equilibrium prices and a big change in equilibrium quantities following a shock. In addition, the adjustment towards the new long run equilibrium is rapid. If, however, the system is price inelastic, prices become very sensitive to exogenous shocks while quantities are less responsive. Moreover, the system's adjustment towards a new long run equilibrium, after a shock, becomes much slower.

The empirical estimates indicate that the supply of freight is very inelastic at high levels of employment at least. However, at the same time the supply of new ships is rather more elastic. Thus freight market shocks are expected to have significant impact effects on rates and prices but these would then tend to adjust quickly because of the rapid response of the fleet. Real world shipping cycles are also characterized by such behaviour.

Simulations of the econometric model also exhibit some qualitative features that the theoretical model cannot reproduce. This reflects the relaxation of some unrealistic assumptions on which the simple model was built. The main qualitative differences in the results arise from the fact that in the econometric model the construction lag is no longer assumed to be zero as well as from the introduction of a new set of equations which describe the dynamic evolution of the age profile.

Since the model is non-linear the solutions are necessarily state dependent. That is the magnitude of the response to a shock will differ, depending on the state of the market in the base run. If the base run is depressed a given change, say, in demand will mostly affect lay-up with little impact on freight rates, ship values and thus shipbuilding and scrapping. If, on the other hand, the freight market in the base run is tight, the shock will greatly affect rates, prices and the fleet. The simulations have been carried our with respect to a base run in which extreme values of the state variables have been intentionally removed in order not to distort the pattern of the simulations.

As is well known, see e.g. Wallis et al (1986), the simulation of rational expectations models necessitates the specification of terminal conditions in order to achieve unique and stable saddle-path solutions. One possibility is to impose equilibrium (long run) terminal conditions. However, if the time horizon of the simulation is relatively short and if this equilibrium is not expected to be achieved within this time period, equilibrium terminal conditions will distort the simulations. Another possibility, which is adopted here, is to require that the rate of change of the state variables in the terminal period is unchanged. This and other terminal conditions have been examined numerically by Wallis et al (1986) who conclude that our choice is more robust. However, the solution values as the terminal date is approached become distorted. These distortions propagate backwards in a damped way. For these reasons the model is simulated over a period of 35 years even though we only report the results for the first twelve years. Our algorithms are similar to Wallis' and iterate on the basis of conventional Gauss-Seidel inner loops to solve for the state variables and an outer loop that solves dynamically for the rational expectations variables using the terminal conditions already described.

Since the model incorporates rational expectations we can distinguish between anticipated and unanticipated shocks. The former are assumed to be realised by the market four years before their actual occurrence. A base run set of assumptions is fed into the system and the equilibrium time path of the endogenous variables is calculated by solving the model. To carry out an unanticipated shock, the exogenous variable is changed from year 0 onwards and the new time path of the system is estimated. The new solution and the base run solution are then compared by calculating the percentage differences in the endogenous variables between the two solutions, at various points in time. To carry out an unanticipated shock the exogenous variable is changed from year 4 onwards and the market is allowed to speculate on the basis of this, from year 0. The new solution is calculated and it is again compared to the base run by calculating the percentage differences in endogenous variables.

Overview of model behaviour

Because the model incorporates rational expectations, shocks to exogenous variables may cause overshooting in prices, rates and other variables. These features and other model properties will become more apparent in the following simulations of the empirical model. Nevertheless, even at this stage an overview of the model is most probably useful for understanding the following sections.

Various dynamic interdependencies between freight rates, prices and the size of the fleet exist. On the one hand, a smaller fleet implies higher freight rates. On the other hand higher rates imply higher prices. In turn higher prices imply a higher fleet because of the positive effect of prices on the supply of newbuildings and the negative effect on scrapping.

Because of these interactions, the impact of an exogenous shock, such as an increase in demand, that tends to raise current and expected future freight rates, will be moderated by the positive effect of higher rates on values and consequently on the growth rate of the fleet.

One way of interpreting the way the model calculates the equilibrium price and other variables is the following: Given the assumption of , say, a higher level of demand for freight the model will allow prices to jump immediately. This jump reflects rational speculation of an upward pressure of demand on future rates and profits but also reflects the moderating impact of the likely endogenous response of the fleet to the higher demand. Indeed, the size of the equilibrium speculative jump in prices is limited and also determined by the fact that higher values will raise the growth rate of the fleet which will generate a downward pressure on future freight rates which creates a danger that a competitive return might not be earned on the initial high price. At equilibrium, values just rise to that level where the higher exogenous demand in conjuction with the higher fleet - caused by the endogenous boom in ship values and shipbuilding - will lead to such a freight rate and profit path which will just allow a competitive return to be earned on the initial price.

Higher prices than the equilibrium one are rejected by the model because they imply even larger shipbuilding expansion and scrapping reduction which will generate further downward pressure on rates which in conjuction with the higher initial price will not allow a sufficient return to be earned. Similarly, lower price than the equilibrium one are also rejected because of speculation that this will restrain shipbuilding and raise scrapping so that the implied higher freight rate and profit path, in conjuction with the lower initial price, will lead to an excess return.

Thus the dynamics of the model are materially different from those exhibited by conventional models which embody backward looking adaptive expectations mechanisms. In the latter case, booms in ship values and shipbuilding reflect belated and irrational reaction to lagged profits and rates. Here, however, booms in ship values and shipbuilding rather reflect a forward looking reaction to anticipated future external events, as investors rush to take speculative positions in new and second hand ships, and in the process alter their values and the newbuilding and scrapping supply, until shipping investment is just expected to realise a competitive return, given the assumptions. This speculative bidding of values reflects both external events but also the expected endogenous reaction of shipbuilding and scrapping to changes in prices which is imbedded in the model itself. Hopefully, these relationships will become clearer in the following sections.

4.4.1 Demand Shocks

Table 4.3 shows the response of the system to a demand shock which raises the level of demand permanently by 10%. The table distinguishes between the cases where the shock is anticipated or not. Columns with an "*A*" heading refer to the results of an anticipated shock while those with a "*U*" heading refer to the results of an unanticipated shock.

Table 4.3

SIMULATED EFFECTS OF A 10% INCREASE IN THE LEVEL OF DRY CARGO DEMAND[3]

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.2	42.3	-0.2	33.4	0.01	-1.24	8.1	44.7
1	-1.1	38.5	-0.9	29.9	0.06	-1.09	12.0	34.0
2	-3.0	31.6	-2.6	24.7	0.15	-0.94	19.2	26.6
3	-6.2	24.5	-5.3	19.3	0.32	-0.81	32.9	20.0
4	30.6	18.6	23.9	14.7	-0.63	-0.71	24.8	15.0
5	23.6	13.8	18.6	11.0	-0.58	-0.62	18.6	11.3
6	17.7	10.3	14.1	8.2	-0.52	-0.53	14.0	8.8
7	13.3	7.8	10.5	6.3	-0.46	-0.46	10.6	7.1
8	10.0	6.2	8.0	5.1	-0.41	-0.40	8.4	6.1
9	7.8	5.3	6.2	4.3	-0.36	-0.35	6.8	5.5
10	6.2	4.6	4.9	3.7	-0.31	-0.31	5.8	5.0
11	4.9	4.1	3.8	3.3	-0.27	-0.26	5.1	5.0
12	4.0	3.8	3.0	3.0	-0.22	-0.23	4.8	5.1

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.1	0.3	0.0	0.0	-0.14	-0.65
1	0.3	1.3	3.7	10.1	-0.29	-1.00
2	0.9	2.7	9.0	16.7	-0.46	-1.04
3	1.9	4.2	16.3	17.1	-0.67	-0.94
4	3.2	5.5	18.6	14.1	-0.81	-0.83
5	4.6	6.6	16.4	10.4	-0.90	-0.82
6	5.8	7.4	12.6	7.4	-0.85	-0.69
7	6.8	8.1	9.1	5.5	-0.77	-0.57
8	7.6	8.5	6.5	4.3	-0.63	-0.43
9	8.2	8.7	4.9	3.7	-0.55	-0.36
10	8.6	8.9	4.0	3.2	-0.53	-0.36
11	8.9	9.1	3.4	3.1	-0.47	-0.33
12	9.2	9.2	3.2	3.1	-0.42	-0.31

[3] percentage changes.

Lay-up, Scrapping: changes in percentage point.

Unanticipated increase in demand

When the shock is unanticipated there is a tightening of the freight market in year 0 which causes freight rates to increase by 33.4%. This in turn causes an increase in the time charter rate of around 42.3%. The increase in current profitability has a positive effect on values. In addition, the positive impact of demand on the freight market balance is expected to last for some time as the fleet can respond with a finite speed only. This makes room for further speculative increases in prices. The increase in prices is not proportional to short term profitability because it also depends on the anticipated increase in longer term profitability. The latter is less than the former because of the anticipated response of the fleet.

The equilibrium speculative jump in values is constrained by the fact that higher prices tend to raise the growth rate of the fleet and this tends to bring down freight rates and profits in the longer term. The equilibrium jump in ship values in year 0, when the shock is realized, is 44.7%. This reflects the fact that over the longer term the fleet is expected to respond and rates will come down. Indeed the increase in ship values immediately reduces scrapping. On the other hand deliveries cannot respond in year 0 since they are predetermined by decisions taken in the past. Nevertheless, the fleet still rises by 0.3% in year 0 because of the drop in scrapping.

The higher values anticipated over the future, raise the prices of newbuildings. This leads to an updating of plans regarding the future supply of newbuildings. The planned future supply of newbuildings increases and the construction of new ships to be delivered in the future is immediately increased. This raises deliveries in the next year by 10%. Scrapping is also lower in the next year by 1 percentage point and this raises the fleet by 1.3%. In year 2 deliveries rise even further to 16.7% as the shipbuilding industry fully adjusts to the new conditions. Scrapping also falls by 1.04 percentage points in year 2. The cumulative effect of these changes in deliveries and scrappings is to raise the fleet by 2.7%.

This increase in the fleet size together with the 10% permanent increase in demand implies that in year 2 the freight market balance is 7.3% higher relative to the base run. The market balance begins to moderate from its full 10% initial increase in year 0 when the fleet was fixed. The fleet response continuously reduces the initial gains in freight market balance and gradually brings freight rates down. In anticipation of these trends and the realization that the increase in profits is short term, prices also begin to ease but still remain above base run levels. The latter implies higher shipbuilding and lower scrapping. Over the next few years the increase in the fleet is even higher even though prices are already receeding. This only reflects the fact that the initial response is small due to the lag between ordering and delivery. The response of shipbuilding reaches its maximum in year 4 when deliveries are 17.1% up.

Over time the changes in fleet size are accumulated and cause the fleet to grow continuously higher and rates to come down. This reduces prices even further which tends to moderate the increase in the fleet such that the system makes a soft landing to long run equilibrium. In this equilibrium the accumulated changes in scrapping and deliveries cause the fleet to increase by almost as much as demand thus bringing rates down to their base run level. Because of this prices also come down to their base run level and there are no more changes to scrapping and shipbuilding. The situation is now stable with almost no long run change in prices, fleet growth rate, and freight rates. However the fleet is permanently higher by a level which is similar to the increase in demand in percentage terms.

Anticipated increase in demand

In the anticipated case the permanent increase in demand takes place in year 4. However the market reacts in year 0 when the shock is first expected. In the anticipated case similar long run responses to the unforeseen case are implied. However the short term reactions of the market are very different. Prices jump in year 0 in anticipation of the positive effects of the shock on future profitability. The size of the jump is smaller than in the unanticipated case. This is both because the future benefits lie in the more distant future and thus they are more heavily discounted but also because of the fact that in the meantime the fleet is likely to respond. This will cushion the eventual impact of the shock. Thus ship prices initially jump by 8.1%. The increase in prices causes an immediate reduction in scrapping and an expansion in the supply of new ships as measured by the order-book. The latter is translated into higher deliveries in the following years. However, demand has not risen as yet so the larger fleet cause a deterioration of freight market balance and so rates drop. Before the shock, the fleet continues to rise further and rates drop even more. These movements can be seen in table 4.3.

Because of the immediate reduction in scrapping the fleet initially increases by only 0.1%. The shipbuilding industry also begins to adapt to the new outlook of higher expected future prices and shipbuilding deliveries increase in the first few years before the shock, except for year 0 when they are predetermined. From year 0 onwards the fleet increases even further so that by year 3 the increase is almost 1%. As a result of these speculative developments in the size of the fleet, freight rates and time charter rates begin to fall because the increase in demand has not yet occurred. They reach an all time low at year 3 just before the occurrence of the shock when the accumulated increase in the fleet size pushes the freight market balance to its lowest level.

Inspite of the drop in rates, prices increase further as the market realizes the temporary nature of the drop.

As the date of the shock is approached the drop in rates caused by the speculative increase in the fleet becomes a thing of the past while the positive effects of the increase in demand now lie in the more immediate future and thus are less heavily discounted. Ship values reach an all time high of 32.9% just before the occurrence of the shock when the expected profit profile is at its highest. This figure is less than the maximum increase of 44.7% when the shock was unanticipated because the speculative increase in the fleet has moderated future increases in profits.

When the shock finally occurs in year 4 it raises freight rates by 23.9% and time charter rates by 30.6%. This is less than the maximum increase in the unanticipated case and it is due to the fact that the speculative increase in the fleet before the shock moderates the effect on rates. Ship values are at an all time high just before the shock when the profit outlook is at its highest. Because the increase in values has been anticipated ever since year 0 there has been plenty of time for shipbuilding to respond. Shipyards take advantage of this expected peak in prices and the peak in the supply of new ships occurs about the same time. In the unanticipated case shipbuilding supply could not respond to the initial unexpected boom in prices and it was therefore at its lowest when prices where at their highest.

Thereafter, the system follows a very similar path as in the unanticipated case. The higher demand causes and improvement in the freight market balance and its positive effects last for some time as the fleet responds with finite speed. Prices begin to ease from their high level as the fleet response lowers the profit profile. This in turn induces a deceleration in the rate of increase in the fleet size and the system makes a soft landing to the new long run equilibrium. This involves little change in the system's variables except the fleet itself which has risen by almost the same amount as demand.

Comparing the two shocks we find that in the unanticipated case the peaks in all variables except deliveries are higher than in the anticipated case. Because the response of deliveries to unanticipated changes in prices is sluggish, scrapping becomes relatively more important for raising the fleet when the shock comes as a complete surprise. When the shock is foreseen the fleet can respond more fully and deliveries now become relatively more important.

4.4.2 Bunker price shocks

We now consider the effect of a change in the price of fuel. The price of fuel affects the supply of transportation services in the freight market through the incentive to slowsteam. In the recent past changes in the price of fuel have resulted from OPEC policies that changed the price of oil through manipulation of supply. The oil shocks were followed by a world recession that reduced the level of demand in the shipping freight markets. Here we investigate purely the effects of the change in the price of fuel by keeping demand fixed at the base run level. The simulations performed here should not therefore be expected to replicate the effects of the oil shocks of the seventies. This is because these shocks involved both a change in the price of fuel and a change in the level of demand for freight. The latter depressed the market. Here we isolate the effects of the former by keeping everything else, including demand, constant. It will be seen that a hypothetical increase in fuel prices will *ceteris paribus* lead to a boom in the shipping markets through its restraining effects on supply.

Unanticipated increase in bunker prices

Table 4.4 shows the effects of a doubling of the fuel price on the dry cargo market. The results are quite similar to the demand shock case. This is because an increase in the fuel price will create a shortage in the

Table 4.4

SIMULATED EFFECTS OF A 100% INCREASE IN BUNKER PRICES[4]

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.3	65.6	-0.2	67.9	0.01	-1.10	11.1	65.4
1	-1.5	58.7	-1.2	60.7	0.08	-1.15	16.8	50.5
2	-4.1	47.5	-3.3	51.5	0.21	-1.07	27.5	38.3
3	-8.3	36.6	-6.7	42.5	0.45	-0.99	48.4	28.7
4	47.1	27.5	51.2	34.8	-0.41	-0.93	36.1	21.6
5	35.3	20.4	41.4	28.7	-0.57	-0.87	26.8	16.4
6	26.0	15.0	33.5	24.0	-0.62	-0.81	19.9	12.7
7	19.0	11.2	27.5	20.7	-0.63	-0.76	14.8	10.1
8	14.0	8.5	23.2	18.4	-0.63	-0.72	11.2	8.3
9	10.5	6.9	20.2	16.9	-0.62	-0.69	8.6	6.9
10	7.9	5.6	17.9	15.8	-0.61	-0.66	6.7	6.1
11	6.0	4.7	16.2	15.0	-0.58	-0.62	5.5	5.6
12	4.6	4.1	15.0	14.5	-0.55	-0.59	4.9	5.4

Year	Fleet		Deliveries		Scrapping Rate (%)	
	A	U	A	U	A	U
0	0.1	0.4	0.0	0.0	-0.18	-0.87
1	0.5	1.7	5.1	14.0	-0.39	-1.30
2	1.2	3.6	12.5	23.4	-0.61	-1.35
3	2.5	5.6	23.1	24.0	-0.89	-1.23
4	4.3	7.4	26.6	19.7	-1.07	-1.11
5	6.2	8.9	23.4	14.6	-1.19	-1.10
6	8.0	10.1	17.9	10.5	-1.13	-0.95
7	9.4	11.0	12.9	7.8	-1.04	-0.81
8	10.5	11.7	9.2	6.2	-0.86	-0.62
9	11.3	12.1	6.8	5.2	-0.75	-0.52
10	11.9	12.4	5.2	4.5	-0.71	-0.51
11	12.3	12.6	4.2	4.1	-0.62	-0.45
12	12.7	12.8	3.5	3.8	-0.53	-0.39

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[4] percentage changes.

Lay-up, Scrapping: changes in percentage points.

freight market through its restraining effect on supply. Because demand is completely inelastic this will raise freight rates to such an extent that profits will also increase.

Thus the impact effect of the bunker shock on profitability is the same as the effect of an increase in demand. Moreover the freight market affects the ship markets only through changes in profitability. In addition demand or fuel prices do not affect the ship markets directly but only indirectly through their effect on profits and this implies that demand shocks and bunker shock will also have similar effects on the ship markets. Thus the dynamic effects of a bunker shock will also be similar to that of a demand shock. This can be seen from a comparison of tables 4.3 and 4.4. Therefore, in order to avoid repetition, the discussion here is very brief as the analysis of the previous section also applies to this case.

When the shock is unanticipated freight rates increase by 67.9% in year 0 as the increase in fuel creates an incentive to slow steam. Time charter rates increase by roughly the same amount while profits increase even more. Prices increase by 65.4% The increase in prices is moderated by the expected response of the fleet. Indeed scrapping immediately falls by 0.87 percentage points while deliveries are predetermined in year 0. Second hand values are expected to be higher in the future and this raises newbuilding values and causes an expansion in the planned supply of new ships. Thus the following year deliveries increase by 14% and scrapping drops by 1.3 percentage points. Deliveries reach a maximum at year 4 and by that time the fleet has grown by 5.6% bringing rates down. The anticipation of these developments causes prices to fall continuously from the initial high point and this tends to restrain the expansion of the fleet.

The process stops when the fleet responds fully and this brings profits almost down to their base run level. As a result prices also come down to their base run level. Freight rates however are permanently higher.

Higher rates are needed in order to cancel the adverse effects of bunker price on profits. The latter is required to support prices at the level which will enable the fleet to grow in line with demand. The fleet also increases in the long run by about 12.8%. Because demand is the same this implies that there is permanent slow steaming.

Anticipated increase in bunker prices

When the shock is anticipated to occur in year 4, a 11.1% speculative increase in prices occurs in year 0. This raises the fleet and brings rates down because as yet bunker prices have not increased. Scrapping immediately drops by 0.18 of a percentage point which reflects the strengthening of prices. The order-book immediately expands and this causes an increase in deliveries from year 1 onwards. Deliveries increase by 5.1% in year 1, 12.5% in year 2 and 23.1% in year 3. As the fleet is increasing and rates drop, prices continue to make speculative gains. This reflects the approach of the shock and bullish profit expectations as the drop in rates caused by the speculative increase in the fleet becomes a thing of the past.

Freight and time charter rates reach an all time low just before the occurrence of the shock when the accumulated increases in the fleet size have depressed the freight market balance. Prices are at that point in time at their maximum as the shock is imminent and the future profit profile is at its highest. Because the peak in ship values is anticipated, shipbuilding also peaks at around the same time. When the shock actually occurs freight rates increase by 51.2% and time charter rates by 47.1%. This is less than the maximum increase in the unanticipated case. This is because the increase in the fleet has dampened the eventual increase in rates. From then on all the variables, with the exception of shipbuilding, follow a similar path to the unanticipated case. The fleet continuous to grow and prices fall until they return to the base run level. This arrests the process of fleet increase and the market settles.

By comparing the two cases we again find that the peaks for all variables except deliveries are higher in the unanticipated case than in the anticipated case. In the former case reductions in scrapping become relatively more important for raising the fleet rather than increases in deliveries the response of which is sluggish. In the latter case where shipbuilding can respond more fully to the anticipated changes, deliveries play a bigger role in raising the fleet.

4.4.3 Shipbuilding Cost Shock

This section considers the effects of an increase in shipbuilding costs on the equilibrium time path of the system. The results are shown in Table 4.5. Prices of shipbuilding inputs affect directly the supply curve in the shipbuilding market. An increase in prices tends to reduce the supply of new ships at a given level of ship values. This makes room for higher ship prices.

Unanticipated increase in shipbuilding costs

An unexpected increase in shipbuilding costs leads to an immediate speculative jump in values. The shock is expected to restrain the growth rate of the fleet and raise future profits. Table 4.5 shows that an unforeseen 50% increase in the general level of building costs causes an immediate increase in values of 4.7%. This reflects the expected increase in future profits caused by the drop in future deliveries which in year 1 fall by 10.4% followed by a 15.4% in year 2. This causes a slight increase in rates during those years. However in year 0 rates drop. This is because in year 0 deliveries are predetermined by past decisions and cannot respond to the unexpected change in prices. Scrapping on the other hand drops immediately following the rise in prices. This increases the fleet and causes the initial drop in rates. From year 1 onwards however deliveries begin to adjust to

Table 4.5

SIMULATED EFFECTS OF A 50% INCREASE IN SHIPBUILDING COSTS[5]

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	0.0	-0.1	0.0	-0.1	0.00	0.01	0.6	4.7
1	-0.1	0.1	-0.1	0.1	0.01	0.00	0.8	6.5
2	-0.2	1.1	-0.2	0.9	0.01	-0.05	1.3	8.3
3	-0.5	2.4	-0.4	1.9	0.02	-0.10	2.3	9.8
4	-0.9	3.7	-0.7	2.9	0.04	-0.14	3.8	10.8
5	-0.7	4.6	-0.6	3.6	0.03	-0.18	5.8	11.5
6	0.5	5.2	0.4	4.1	-0.01	-0.20	7.7	11.8
7	2.0	5.5	1.6	4.4	-0.06	-0.21	9.1	12.1
8	3.4	5.8	2.7	4.6	-0.10	-0.22	10.2	12.2
9	4.5	6.1	3.5	4.8	-0.14	-0.23	10.9	12.3
10	5.1	6.2	4.0	5.0	-0.16	-0.23	11.3	12.3
11	5.5	6.3	4.3	5.0	-0.17	-0.23	11.6	12.3
12	5.7	6.3	4.5	5.1	-0.18	-0.22	11.8	12.4

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.0	0.1	0.0	0.0	-0.01	-0.08
1	0.0	0.0	0.3	-10.4	-0.02	-0.12
2	0.1	-0.3	0.6	-15.4	-0.04	-0.16
3	0.1	-0.7	1.1	-16.3	-0.05	-0.20
4	0.3	-1.0	1.9	-15.5	-0.09	-0.24
5	0.2	-1.2	-9.5	-14.4	-0.11	-0.32
6	-0.1	-1.4	-15.2	-13.6	-0.15	-0.35
7	-0.5	-1.5	-16.6	-13.2	-0.20	-0.37
8	-0.9	-1.5	-16.0	-13.0	-0.24	-0.35
9	-1.1	-1.6	-14.9	-13.0	-0.29	-0.36
10	-1.3	-1.6	-14.0	-13.0	-0.36	-0.41
11	-1.4	-1.6	-13.6	-13.1	-0.40	-0.42
12	-1.4	-1.7	-13.4	-13.1	-0.43	-0.46

[5] percentage changes.

Lay-up, Scrapping: changes in percentage points.

the shock and this reduces the fleet.

The main impact of the shock on rates, values, the fleet size and scrapping is felt in the long run. The ongoing cutbacks in deliveries cause a continuous reduction in the fleet and a parallel improvement in market balance, rates and values. In the long run time charter rates increase by 6.3% while prices rise by 12.4%. The latter causes a partial recovery in deliveries and a sufficient cutback in scrappings so that the fleet reduction is halted. In the meantime however the fleet size has fallen permanently by 1.7%. Higher prices will partly offset the negative impact of higher costs on the supply of new ships, while in addition they will reduce scrapping. Thus the partial recovery of deliveries and the reductions in scrappings will raise the growth rate of the fleet back to its base run level. The freight market balance will however improve permanently as in the mean time the fleet growth rate has remained below the base run level.

Anticipated increase in shipbuilding costs

When the shock is anticipated, similar long run changes are implied. Here too there is an initial speculative increase in values at time 0 when the market realizes the future shock. In the short term, however, there is a more significant drop in rates and market balance. This reflects the fact that the increase in values reduces scrapping which tends to raise the fleet. In addition, because shipbuilding costs have not as yet risen, the supply of new ships expands following the increase in values.

There is a speculative build-up in the size of the fleet up to year 4. Prices continue to move upwards in spite of the drop in rates as the market moves closer to the time when the shock will occur. After year 4 deliveries begin to drop sharply as higher costs restrain the supply of new ships. The drop in deliveries quickly cancels the initial speculative increase in the fleet size. This occurs in year 6 when the market balance and rates rise above their base run levels. Further gains in balance, rates and prices are achieved in the following years as deliveries remain at a low level. Eventually this helps the recovery of profits and prices which permanently reduces scrapping and causes a partial recovery in shipbuilding such that the fleet stabilizes at a permanently lower level.

4.5 Historical Simulations

Conventional econometric models which contain no forward looking rational expectations variables can be used for the purpose of historical simulations. These can be used in order to construct measures of the "explanatory power" of the model, e.g. root mean squared errors (RMSE), based on the deviation of the simulated path of the system from the actual path. The deviation reflects possible misspecification and the net effect of disturbance terms which in turn reflect the influence of factors that have not been taken into account. The smaller these deviations are, the higher the explanatory power of the model.

Rational expectations models can also be simulated in a rather more complicated way. Because expectations of future exogenous variables appear in the final reduced form of rational expectations models, a historical simulation of the whole model can only be performed if measures of such expectations are available. In our case this could be done by using the actual forward values of these variables as proxies for the expectations. In this case however the deviation between the simulated and the actual path would not just reflect possible misspecification or disturbances in structural equations but also the deviations between unobservable market expectations of exogenous variables and the proxies being used. Although such simulations might be useful for determining the stability and other properties of the model, the use of RMSEs as measures of the explanatory power would be an unfair test of the model. This is because the simulation is conditioned on proxies rather than actual market expectations of exogenous variables and thus large deviations and inflated RMSEs might reflect deviations between the proxies and the variables they intend to measure and not the quality of the model.

However, our freight market block is recursive with respect to the rest of the model and in addition it does not contain any forward looking rational expectation terms. Thus it can be simulated like other conventional econometric models with the predetermined fleet treated as an exogenous variable as in Wergeland (1981).

The freight market block consists of equations (1), (2), (3) and (4). These equations solve for the equilibrium level of freight rates (F), trading fleet (Kv), lay-up (λ) and supply (q^{s}) in terms of a set of exogenous variables, which includes the level of demand (q), unit voyage costs (Pb) and operating costs (OC) and also in terms of the size of the fleet K which is predetermined by historical movements in shipbuilding and scrapping.

The econometric versions of equations (1), (2), (3), (4), reported in Table 4.2, have been used to calculate the dynamic simulation of the freight market submodel. According to the theory the level of freight rates and lay-up should reflect the demand for freight relative to the size of the fleet as well as other factors such as bunker prices and operating costs that might have an influence on supply. The historical dynamic simulations performed here calculate the model's predictions on rates and lay-up that would have been generated conditional on information regarding the path of the exogenous variables such as demand, fuel and operating costs as well as the size of the fleet. Historical simulations indicate the extent to which a model broadly tracks the past. Certainly a model which is claimed to be useful for forecasting purposes should be able to track the past movements with some accuracy. The reverse however is not true. Good historical tracking is a necessary but not sufficient condition for forecasting ability.

The simulation results of the freight market submodel are shown on Fig. 4.1 and 4.2. The former shows the actual and simulated paths of the nominal freight rate while the latter does the same for lay-up. It can be seen that the model tracks the actual historical movements quite accurately.

Root mean square errors, the Theil inequality coefficient and other standard criteria that can be used to evaluate the simulation model are reported in Table 4.6. The first row of the table reports the correlation coefficient between the historical and the simulated series and partly indicates the tracking ability of the model. This should ideally be equal to 1. The correlation for the freight rate is equal to 0.97 while for the lay-up it is slightly lower at 0.927.

Row 3 reports the Root Mean Square percentage error and this is 10.58% for the freight rate and 5.65% for the lay-up. These figures are quite acceptable given also the volatility of the two series (Figs 4.1 - 4.2).

The figures reported in rows 2, 4, 5 are not very informative on their own. They can be more revealing if compared with the mean of the historical series which is reported at the bottom of the table. The mean freight rate is 68.94 while lay-up, which is expressed as a fraction of the fleet, has averaged out at 0.01562 over the sample period. Comparison of the elements in rows 2, 4 with the corresponding mean of the series also indicate that the tracking of the simulation is acceptable as has already been indicated by the RMS percent error. Comparing the Mean Error reported in row 5 with the mean of the series suggests that there is little bias in the simulation.

Row 6 reports the regression coefficient calculated from a regression of the actual on the simulated series. It can be seen that this is very close to the ideal value of 1.

The following rows report the Theil inequality

FIG. 4.1


FREIGHT RATE
150
140
130
120
110
100
90
80
70
60
50
40
30
62
64
66
68
70
72
74
76
78
80
82
84
86
ACTUAL
SIMULATED

FIG. 4.2

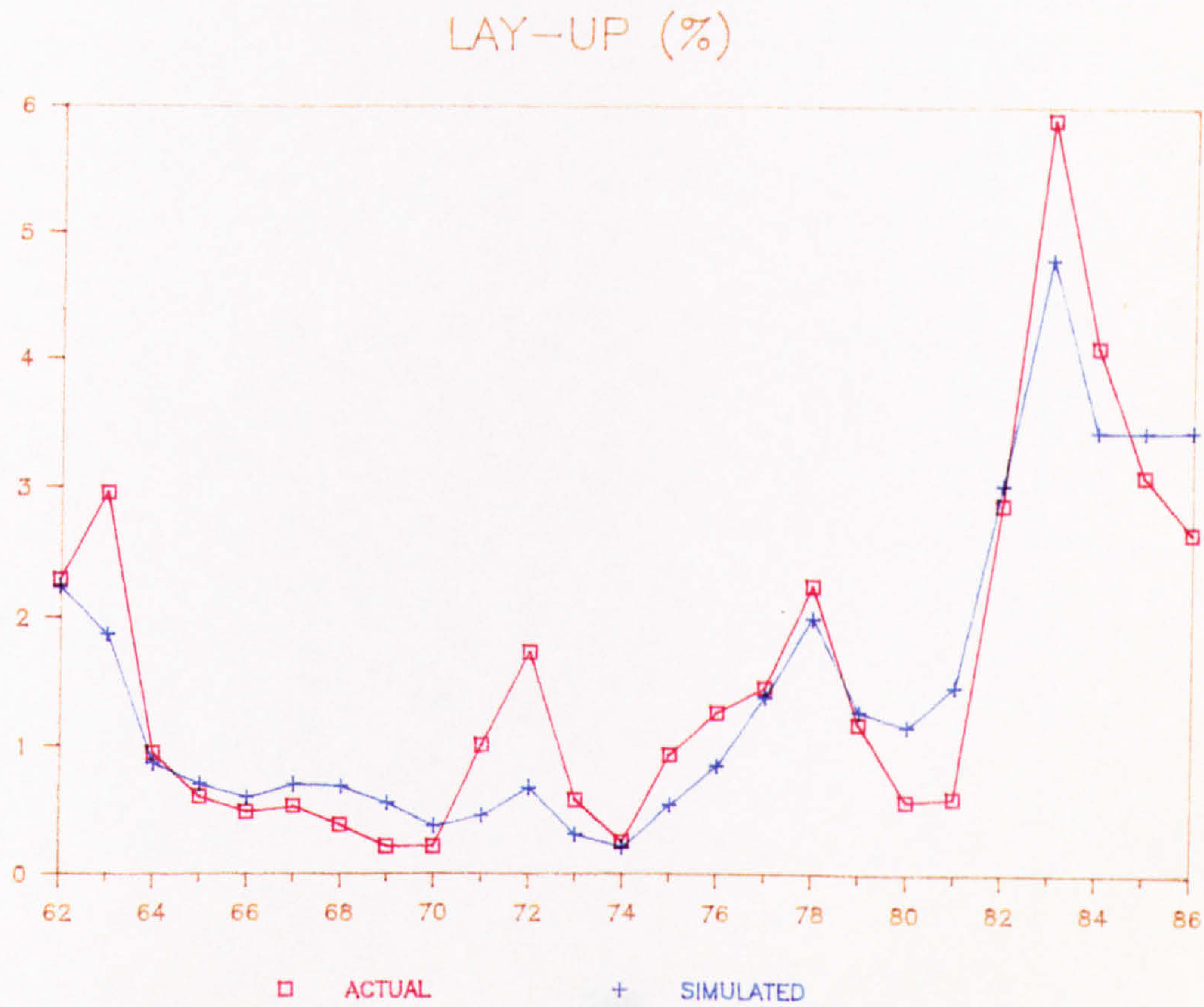
LAY-UP (%)
6
5
4
3
2
1
0
62
64
66
68
70
72
74
76
78
80
82
84
86
ACTUAL
SIMULATED

Table 4.6

Results of historical simulation

	Freight Rate	*Lay-up (%)*
Correlation coefficient	*0.970*	*0.927*
Root-mean-squared error	*7.332*	*0.005*
RMS percent error	*10.58%*	*5.65%*
Mean absolute error	*5.988*	*0.004*
Mean error	*0.228*	*0.001*
Regression coefficient	*0.993*	*1.051*
Theil's inequality coeff	*0.0095*	*0.0635*
Fraction of error due to		
Bias	*0.0009*	*0.0230*
Different Variation	*0.0097*	*0.0954*
Different Covariation	*0.9894*	*0.8816*
Mean	*68.94*	*0.0156*

coefficient and its decomposition. The calculated coefficient is quite small and very close to the ideal value of 0, especially in the case of freight rates. The decomposition between bias, different variation and different covariation is also good and close to the ideal 0,0,1 distribution. This is again especially true for freight rates, while in the case of lay-up the figure for different variation is rather more important but still quite small. This result indicates that, unlike in the case of freight rates, the simulated lay-up series cannot replicate entirely the volatility of the actual series.

These results are encouraging for the aggregate approach we have adopted. By using a simple framework, the significant oscillations in rates and lay-up have been explained in terms of basically three main variables; freight market balance (q/K), unit voyage costs (P_b) and operating costs (OC).

CHAPTER 5

THE TANKER MODEL

PAGE

NUMBERING

AS ORIGINAL

5.1 Introduction

In the previous chapter we developed an econometric model of the dry cargo market using the theory of chapter 3 as a basis. In this chapter an econometric model of the tanker market is developed based on the same theory. The model consists of a freight, second hand, shipbuilding and scrapping market. Again here the level of aggregation reflects a balance between on the one hand the likely improvements that this would imply and on the other the costs of carrying out such an extension. As in the dry cargo market, aggregate demand and supply equations for freight, second hand, shipbuilding and scrapping markets are estimated. There is some disaggregation in the scrap market only, where separate scrapping supply functions are estimated for each age group.

There is some evidence that the smaller and larger tankers are not perfectly substitutable in the freight market and consequently in the second hand, shipbuilding and scrapping markets as well. This is due to the fact that there is a number of routes which - because of port and canal draft restrictions - cannot accommodate large vessels. This can cause the freight rates of the various tanker vessels to be less than perfectly correlated. In spite of this however the individual freight rates have historically fluctuated very closely together. Because the large vessels have only appeared relatively recently it would be difficult to estimate econometrically a separate model of the large tanker sector because of the limited degrees of freedom that the small sample of observations implies. There are also numerous links between the small and large vessels through the demand and the supply sides of the markets that makes it difficult to disaggregate the two both in theory and from the data. For example taking the demand side of the freight market, a shipper can, instead of chartering a large vessel, use a number of smaller vessels and in actual practise this will depend on relative freight rates. On the supply side now large vessels can carry part cargoes and thus can operate as if they were smaller ships. The decision to carry part cargo will again depend on the relative freight rates. These widely available substitution possibilities will not allow the various freight rates to diverge very much.

In the light of the above arguments and in spite of the fact that there are some good reasons for distinguishing between tankers of various sizes, we have chosen not to disaggregate further.

The theoretical specification of the model and the econometric methodology used in order to estimate its structure, is almost identical to that used for the construction of the dry cargo model presented in the previous chapter. In section 5.2 therefore the theoretical specification to be estimated is briefly reviewed. In section 5.3 the econometric methodology is explained and then the empirical estimates are presented and discussed. Finally in section 5.4 the model's dynamic multipliers are calculated by simulating its response to various anticipated and unanticipated shocks.

5.2 Overview

This section presents the theoretical specification of the tanker model. This is almost identical to the one used in the previous chapter for the construction of the dry cargo model and thus the presentation is brief. The theoretical specification is based on the theory which was presented in chapter 3. The theory of chapter 3 is extended in order to take account of not only additional dynamics and exogenous influences but also aspects of behaviour that have up to now been ignored.

The complete specification of the model is given by

Table 5.1

Model Listing

$$q^s = F_1(Kv,\ F/Pb,\ Zq) \tag{1}$$

$$Kv = (1-\lambda)K + p_o Kc - ST \tag{2}$$

$$\lambda = F_2(\ F,\ Pb,\ OC,\ LC) \tag{3}$$

$$q = q^s \tag{4}$$

$$\pi_t = (F_t^{1+\gamma}/Pb_t^{\gamma}) - OC_t \tag{5}$$

$$lnH_t = (1+\gamma)E_t lnF_{t+1} - \gamma E_t lnPb_{t+1} + \mu \tag{6}$$

$$P_t = F_4(\ W_t/K_t,\ E_t\pi_{t+1},\ E_t P_{t+1},\ r_t) \tag{7}$$

$$Q = F_5(\ Pn,\ Pn',\ Pi,\ Pi';\ Z_Q) \tag{8}$$

$$D_t = \sum w_i Q_{t-i} \tag{9}$$

$$Pn_t = E_t P_{t+1} + k \tag{10}$$

$$s_i = F_6(\ P/Ps) \tag{11}$$

$$s \equiv A_3 s_3 + A_4 s_4 + A_5 s_5 \tag{12}$$

$$S \equiv Ks \tag{13}$$

$$A_{2,t}K_t \equiv A_{1,t-5}K_{t-5} \tag{14'}$$

$$A_{1,t}K_t \equiv \sum_{j=1}^{5} D_{t-j} \tag{14''}$$

$$A_{i,t}K_t \equiv$$

$$A_{i-1,t-5}K_{t-5}\ (\ 1 - (7/10)\sum_{j=1}^{5} s_{i,t-j} - (3/10)\sum_{j=1}^{5} s_{i-1,t-j}\ )$$

$$i = 3,4,5 \tag{14'''}$$

$$K_t = K_{t-1} + D_{t-1} - S_{t-1} \tag{15}$$

equations (1)-(15) listed in Table 5.1. Some of these equations contain unknown parameters which in section 5.3 are estimated from the data while others are either identities or equilibrium conditions.

The notation is the same as the one used in the previous chapter only for the fact that, here, variables refer to the tanker market rather than the dry cargo market. A "′" over a variable indicates a dry cargo variable.

Equations (1)-(6) constitute the freight market block which is recursive with respect to the remaining system. Equation (1) captures the positive effects of freight rates on supply which arise out of the incentive to utilize trading ships more efficiently when rates increase. It is derived from the assumption of profit maximization of the ship in a perfect competition environment. Equation (2) is an identity that simply says that the total fleet trading in the tanker market consists of tankers not laid up plus combis in oil minus tankers in storage *ST*. The latter is treated as exogenous. Equation (3) relates the optimal level of lay-up to freight rates and other prices. It assumes that at the margin costs in lay-up are equal to the cost (losses) of operating the vessel in the spot market. Equation (4) states that the freight market clears within the unit time period.

Equation (5) relates the maximum amount of profits earned by trading the ship at the optimum speed to the prevailing freight rates, unit voyage costs and operating fixed costs.

Equation (6) determines the equilibrium time charter rate on a one year time charter hire contract arranged at the end of time t. This is a rent which is paid to the owner by the charterer in return for assuming control of the vessel and for the entitlement to the income generated by the ship while on hire. In theory the rent reflects the expected profitability of the asset over the duration of the contract. Because of the special nature of this charter contract whereby the charterer pays for only part of the costs while the owner pays for the fixed operating costs, the rental rate must now equal the expected profits of the ship before fixed operating costs. In shipping terminology profits before fixed costs is referred to as the time charter equivalent and this is equal to the first term of the LHS of equation (5). Equation (6) equates the time charter rate to expectations regarding this term after allowing for a risk premium.

Equations (7)-(15) represent the ship markets block of the model. Equation (7) relates the equilibrium price of ships to the expected profits, next period prices and alternative returns to capital. When expectations regarding future profits or prices increase then capital tends to flow into shipping and this raises the value of ships until the expectation of excess return is eliminated. The equation also allows for a variable risk premium which at equilibrium moves in line with the ratio of wealth to the total fleet.

Equation (8) is the theoretical supply of newbuildings as measured by the order book. The order book is the product of the stretch of time over which contracts have been arranged and the planned delivery rate that is the amount of ships intended to be delivered per period. The latter depends positively to the newbuilding price relative to shipbuilding costs. The former also depends on the same factors. Since shipbuilders can also produce dry cargo vessels the supply of tankers should be negatively related to the price of dry cargo newbuildings. Equation (9) assumes that deliveries are determined by a lagged distribution on past orders. We assume a one year average lag between order and delivery and this implies that the price of tanker newbuildings should reflect expectations of next year's equilibrium second hand values as equation (10) indicates.

Equation (11) is the theoretical supply of tankers for scrap generated by the individual age groups. There are again 5 age groups. These are the 0-5, 5-10, 10-15, 15-20 and 20 years and over. These are indexed by i = $1,2,3,4,5$. In the light of the empirical evidence we assume that there is zero scrapping in the first two age groups. In reality there has been some scrapping of 5-10 year old tankers during the recent depression. However this has been very small and an isolated event in the long term history of the market. For the remaining age groups we assume that the supply of tankers for scrap depends on the second hand values of tankers relative to demolition prices.

Equation (12) is an identity which says that the aggregate scrapping rate is a weighted average of the specific age group scrapping rates with the weights being equal to the proportion of ships within each age group. Equation (13) is also an identity which simply says that total scrappings are equal to the aggregate scrapping rate times the size of the fleet. Identities (14'), (14'') and (14''') describe the dynamic evolution of the age profile. Equation (14'') simply says that the number of tankers in the first age group is equal to the sum of tanker deliveries over the last 5 years. Equation (14') says that, since there is zero scrapping in the first two age groups, the number of tankers in the second age group must equal to the number of tankers in the first age group 5 years ago. Equations (14''') are almost identities that relate the number of ships at age group i to the number of ships in age group $i-1$ 5 years ago, depreciated by a factor which is a weighted average of scrapping rates in these two age groups over the last 5 years. Finally identity (15) simply says that the change in the fleet is equal to the difference between deliveries and scrappings.

5.3 Estimation

The econometric estimation methods used are similar to the ones discussed in the previous chapter section 4.3. The specification presented in section 5.2 above, is the one that is derived from the extended theory analysed in section 4.2. This specification cannot be estimated as it is because data on current profits is not available. Thus equation (5) cannot be estimated. This presents no special problems however. Profits appear only in one other equation. This is the inverted asset demand equation (7). The time charter rate H_t is the rent for hiring a ship on a time charter basis and this, as already explained, should reflect profits before operating costs.

$$H_t = E_t\pi_{t+1} - E_tOC_{t+1} \tag{14}$$

Thus the unobservable profit term in (7) can be eliminated by using (14) to substitute for $E_t\pi_{t+1}$ in terms of H and OC to give the following

$$P_t = F_4(\ W_t/K_t,\ H_t - E_tOC_{t+1},\ Pn_t,\ r_t) \tag{7'}$$

The system to be estimated consists now of the same set of equations (1)-(13) except for (5) which has been omitted and (7) which has been substituted by (7').

5.3.1 Econometric Methodology

Freight Market

The freight market block is recursive with respect to the ship markets since the fleet is predetermined. In addition the parameter γ in equation (6) is equal to the elasticity of supply in equation (1). The recursiveness of the model implies that the freight market block can be efficiently estimated separately from the rest of the system. The cross equation coefficient restrictions on the other hand suggest that the freight market equations should be estimated jointly. Thus the parameters of equations (1), (3), (6) are jointly estimated by 3SLS. This joint estimation takes advantage of the fact that there might be contemporaneous correlation across the disturbance terms of these equations while it also imposes the cross equation restrictions between (1), (3) and (6). This cross equation restriction arises from the fact that the freight rate elasticity γ of (1) is related to the parameters of (6).

Equation (6) involves unobservable expectations of future freight rates and bunker prices. We have used the error in variables method to estimate this equation jointly with (1), (3). The future values of the expectation variables have been used as proxies for these unobservable market forecasts and the disturbance term has been redefined to be a sum of the original disturbance term plus the forecast errors. To do this let us first define the one step ahead forecast errors of freight rates u_t^f and bunker prices u_t^b as

$$u_t^f = F_{t+1} - E_t F_{t+1}$$

$$u_t^b = Pb_{t+1} - E_t Pb_{t+1}$$

Using these definitions, equation (6) can be written as follows

$$lnH_t = (1+\gamma)lnF_{t+1} - \gamma lnPb_{t+1} + \mu - (1+\gamma)u_t^f + \gamma u_t^b \qquad (6')$$

The terms F_{t+1} and Pb_{t+1} are proxies of the current market expectations regarding these variables. Because these terms are correlated with u_t^f and u_t^b we have to use instruments for them. The instruments must be uncorrelated with the u terms in equation (6') in order for the estimates to be consistent. Efficiency also requires that the instruments should be as highly correlated as possible with the proxies. Our instrument list is a subset of the current information set. These are valid instruments since the forecast errors u_t^f and u_t^b are by construction orthogonal to the current information set. In small samples a few good instruments might give better results than if a wider set is used.

We estimate the unknown parameters of (1), (3) and (6) by carrying out 3SLS on the system of equations (1), (3) and (6′). We also need instruments for the current freight rate and lay up which are endogenous variables included as regressors in equations (1), (3). The instruments chosen for current freight rates and lay up are the exogenous and predetermined variables of (1), (3) where the fleet is also treated as predetermined and used as an instrument because of the block recursiveness. These same variables are used as instruments for the future freight rate, which enters in equation (6′), but in addition the current order book has also been included since this is part of the information set and is relevant for forecasting the future fleet and thus freight rate. The current bunker price is used as an instrument for its future value.

Ship Markets

The inverted asset demand equation (7) involves two expectation variables, that is $E_t\pi_{t+1}$ and E_tP_{t+1}. As it is this equation cannot be estimated even by the error in variables method because data on actual profits is not available. This problem can be remedied by using (7′) instead of (7). The other estimation problem is caused by the appearance of the unobservable E_tP_{t+1} term. Fortunately, as equation (10) suggests, the newbuilding price can be used as an index of expected future second hand prices in which case (7′) becomes

$$P_t = F_4(W_t/K_t,\ H_t - E_tOC_{t+1},\ Pn_t,\ r_t) \qquad (7'')$$

This involves only one unobservable expectation term $E_t OC_{t+1}$ which can be easily instrumented even by a simple trend variable. Equation (7'') is thus estimated by the errors in variables method. The only variable that has to be instrumented is the OC_{t+1} term and the instruments used are a subset of the current available information which is particularly relevant for forecasting the future level of operating costs. These costs consist mainly of wages. Current operating costs, fuel prices and interest rates have been used as instruments for OC_{t+1} while the remaining variables are used as instruments of themselves.

This method is expected to give much better estimates than if the original equation had been estimated by the errors in variables method assuming that data on profits was available. This is because of the unpredictability of profits and second hand prices as well as the high correlation between these two variables, which would make it very difficult to instrument them separately. Moreover the variance of the error term would be inflated by the addition of the forecast errors to the original disturbances implied by the error in variables method. Using the newbuilding price as a direct observation of expected future second hand price the variance of the error attributed to the difficulty of instrumenting prices is eliminated. In addition the substitution of the expected profit term by the observable time charter rate and the easily instrumented expected operating cost, also eliminates most of of the variance in the estimates that would be attributed to the difficulty of instrumenting profits. This method is almost equivalent to carrying out OLS since operating costs can be instrumented very easily.

Equation (9) can be estimated efficiently by OLS. Equation (9) involves only predetermined variables since the current order book is excluded from the right hand side of (9) both because of theoretical and empirical reasons. The current order book should have no influence on current deliveries because of the lag between ordering and delivery.

Equation (10) involves only an unknown constant which reflects risk premia but also the arbitrary basing of the two indices. If we denote the ship price forecast error by u^p_t i.e.

$$u^p_t = P_{t+1} - E_t P_{t+1}$$

then equation (10) can be written as

$$Pn_t = P_{t+1} + k - u^p_t$$

or

$$P_{t+1} = Pn_t - k + u^p_t \tag{10'}$$

The unknown parameter k of (10) can be estimated efficiently and without bias by carrying out OLS on (10').

The disturbance term in the scrapping equations (11) were found to be highly autocorrelated. We thus assume that the disturbance term u_t follows a first order autoregressive process, that is

$$u_t = \rho u_{t-1} + e_t$$

where e_t is uncorrelated. We treat the regressors in (11) as fixed and estimate the unknown parameters by maximum likelihood. This is asymptotically equivalent to the traditional Cochrane-Orcutt method but can be more efficient in small samples since it takes account of the first observation rather than dropping it. Instrumental variable estimates of these equations with correction for serial correlation gave similar results.

5.3.2 Results

Table 5.2 shows the econometric estimates. Figures in parentheses are t-statistics which test the hypothesis

Table 5.2 Econometric estimates[1]

Freight Market & Time Charter Rates

3SLS 1962 - 1985

$$lnF = 0.47 + 3.25(lnq^{*} - lnKv) + lnPb - 2.28lnLH \qquad (\hat{1})$$
$$(1.06)\ (17.59) \qquad\qquad (-8.52)$$

$\bar{R}^2 = 0.872,\ S.E = 0.28,\ D.W = 1.62$
$AR_1 = 0.121,\ AR_2 = -0.143,\ AR_3 = 0.089,\ AR_4 = -0.071$
$BL(2) = 0.90,\ BL(4) = 1.26$

$$ln(\lambda/(1-\lambda)) = 7.98 + 0.34ln(\lambda/(1-\lambda))_{-1} - 4.62ln(F/OC)$$
$$(5.52)\ (3.16) \qquad\qquad (7.64)$$

$$- 1.21ln(F/OC)_{-1} + 1.42ln(Pb/OC) + 0.37ln(Pb/OC)_{-1}$$
$$(2.05) \qquad (3.21) \qquad (2.75)$$

$$- 10.76ln(LC/OC) \qquad (\hat{3})$$
$$(-7.08)$$

$\bar{R}^2 = 0.922,\ S.E = 0.77,\ D.W = 1.74$
$AR_1 = 0.132,\ AR_2 = 0.171,\ AR_3 = 0.124,\ AR_4 = -0.093$
$BL(2) = 1.20,\ BL(4) = 1.87$

$$lnH_t = -3.40 + 1.31E_t lnF_{t+1} - 0.31E_t lnPb_{t+1} \qquad (\hat{6})$$
$$(-35.44)$$

$S.E = 0.48,\ D.W = 2.56$
$AR_1 = -0.195,\ AR_2 = 0.065,\ AR_3 = -0.145,\ AR_4 = -0.113$
$BL(2) = 1.06,\ BL(4) = 2.00$

---

[1] Figures in parentheses are t-statistics for testing the null hypothesis that the true value of the coefficient equals to zero. AR(j) is the autocorrelation at lag j and BL(j) is the Box-Ljung statistic which takes account of the residual autocorrelation up to and including lag j. ρ is the autoregressive coefficient of the residuals.

Second Hand Market

Instrumental Variables 1968 - 1985

$$\ln P_t = 0.32 + 0.02\ln(W_t/K_t)$$
$$(0.56)\ (0.13)$$

$$+\ 0.29\ln((H_t - E_tOC_{t+1})/(1 + r_t))$$
$$(2.74)$$

$$+\ 0.71\ln(Pn_t/(1 + r_t)) + 0.35DUM \qquad (\hat{7})$$
$$(6.75 \qquad\qquad (1.68)$$

$\bar{R}^2 = 0.813$, $S.E = 0.191$, $D.W = 1.36$

$AR_1 = 0.204$, $AR_2 = -0.012$, $AR_3 = -0.059$, $AR_4 = -0.450$

$BL(2) = 0.88$, $BL(4) = 6.17$

Scrapping

Maximum Likelihood and first order autoregressive disturbances

1955 - 1985

$$\ln(s_3/(1-s_3)) = -6.51 - 2.24\ln(P/P_*) + 1.04DUMs_3 \qquad (\hat{1}1)$$
$$\qquad (-4.93) \quad (-3.41) \qquad\qquad (1.66)$$

$\hat{\rho} = 0.904$, t - statistic for $\rho = 10.72$

$\bar{R}^2 = 0.642$, $S.E = 0.842$, $D.W = 2.02$

$AR_1 = -0.107$, $AR_2 = -0.147$, $AR_3 = -0.021$, $AR_4 = 0.113$

$BL(2) = 1.15$, $BL(4) = 1.65$

1957 - 1985

$$\ln(s_4/(1-s_4)) = -4.65 - 2.34\ln(P/P_*)$$
$$\qquad (-10.51) \quad (-4.47)$$

$\hat{\rho} = 0.479$, t - statistic for $\rho = 2.78$

$\bar{R}^2 = 0.536$, $S.E = 0.732$, $D.W = 1.33$

$AR_1 = 0.050$, $AR_2 = -0.157$, $AR_3 = 0.163$, $AR_4 = -0.340$

$BL(2) = 0.90$, $BL(4) = 5.98$

1951 - 1985

$$\ln(s_5/(1-s_5)) = -3.76 - 2.15\ln(P/P_*)$$
$$\qquad (-9.45) \quad (-5.12)$$

$\hat{\rho} = 0.596$, t - statistic for $\rho = 4.794$

$\bar{R}^2 = 0.542$, $S.E = 0.596$, $D.W = 1.65$

$AR_1 = 0.073$, $AR_2 = -0.276$, $AR_3 = 0.015$, $AR_4 = -0.086$

$BL(2) = 3.19$, $BL(4) = 3.51$

Shipbuilding

OLS 1952 - 1986

$$lnQ_t = -2.89 + \underset{(4.72)}{0.92lnQ_{t-1}} - \underset{(-2.17)}{0.49lnD_t} + \underset{(5.74)}{1.11ln(Pn_t/Pi_t)}$$
$$(-4.20)$$

$$- \underset{(-3.51)}{0.73ln(Pn'_{t-1}/Pi'_{t-1})} + \underset{(3.30)}{0.76lnCP_{t-1}} \qquad (\hat{8})$$

$\bar{R}^2 = 0.924$, $S.E = 0.234$, $D.W = 1.52$

$AR_1 = 0.252$, $AR_2 = 0.023$, $AR_3 = -0.043$, $AR_4 = 0.067$

$BL(2) = 2.44$, $BL(4) = 2.70$

$$lnD_t = \underset{(-3.93)}{-0.81} + \underset{(4.42)}{0.34lnD_{t-1}} + \underset{(9.75)}{0.52lnQ_{t-1}} - \underset{(-2.48)}{0.26lnQ'_{t-1}}$$

$$+ \underset{(3.52)}{0.50lnCP_{t-1}} \qquad (\hat{9})$$

$\bar{R}^2 = 0.962$, $S.E = 0.148$, $D.W = 1.42$

$AR_1 = 0.241$, $AR_2 = -0.024$, $AR_3 = 0.043$, $AR_4 = 0.021$

$BL(2) = 2.23$, $Bl(4) = 2.33$

Newbuilding Prices

OLS 1966 - 1985

$$lnPn_t = \underset{(5.05)}{0.82} + E_t lnP_{t+1} + \underset{(2.07)}{0.43DUMPn} \qquad (\hat{10})$$

$\bar{R}^2 = 0.546$, $S.E = 0.46$, $D.W = 1.75$

$AR_1 = 0.093$, $AR_2 = -0.124$, $AR_3 = -0.132$, $AR_4 = 0.074$

$BL(2) = 0.58$, $BL(4) = 1.18$

that the coefficients are equal to zero. For the scrapping equations we also report the estimated value $\hat{\rho}$ of the the autoregressive coefficient in the AR(1) specification of the disturbance term. In this case, the statistics reported are based on the ρ transformed variables which are generated by passing the original data through the filter $1-\hat{\rho}L$.

To assist comprehension the estimated equations have been numbered in the same way as the corresponding theoretical ones. Thus equation $(\hat{1})$ is the econometric estimate of equation (1).

Equations (1), (3), (6′) have been jointly estimated subject to cross equation restrictions. The coefficient on $lnq^{s} - lnKv$ in $(\hat{1})$ is the inverse of the elasticity of supply γ when lay-up is kept constant. Its value of 3.25 implies a value for γ equal to 0.31. This is the elasticity of supply when lay-up falls down to zero and cannot therefore be reduced any more. The estimated value of γ is slightly higher here than in the case of the dry cargo market. The elasticity of time charter rates with respect to expected freight rates is $(1+\gamma)$ and this is estimated to be 1.31 while the elasticity with respect to bunker prices is $-\gamma$ which implies a value of -0.31. The average length of haul has been included as an additional regressor in the inverted supply equation $(\hat{1})$. This is because higher distances imply a lower proportion of time spent in port and more productive time in steaming which should therefore increase the supply. In the inverted supply equation it is expected to appear with a negative coefficient.

The lay-up equation $(\hat{3})$ is dynamic. This probably reflects the fact that there are costs of moving in and out of lay-up which usually introduce dynamic complications. The results imply that the short term response of lay-up to freight rates is smaller than the long term one.

Equation $(\hat{7})$ is the estimated second hand equation. It relates prices to expected profits, which can be inferred from the time charter rate after allowing for operating costs, and to expected future second hand values. The coefficient on expected profits and prices are constrained to sum up to one so that the long run response of prices to profits is one. It can be seen that the elasticity of prices with respect to profits is 0.29 which is almost equal to the estimate for the dry cargo market. The elasticity of prices with respect to expected future values on the other hand is estimated to be much higher, around 0.71. This is natural since tankers are assets of considerable longevity and therefore the effect of short term profits should be much smaller relative to the effect of long term profitability as embodied in expected future prices.

Equations $(\hat{11})$ are the estimated scrapping equations for the age groups 10 - 15, 15 - 20 and 20 years and over. The error term in these equations has been assumed to follow a first order autoregressive process. Since the scrapping rate is a 0 - 1 variable the specification for these equations is logistic. The estimated coefficients on the ratio of second hand prices relative to scrap values are negative for all the age groups as expected. They are also surprisingly similar to each other. The value of the constant of the regression increases as we move down from the younger age groups towards the older ones. This simply reflects the fact that at a given level of prices there should be more scrapping in the old age groups rather than in the young ones. The estimates imply that on average during the cycle there is 0.6 percent scrapping in the 10 - 15 years old age group, 4% scrapping in the 10 - 15 years group while for the older age group this figure rises to 8.2%. At the bottom of the depression where second hand values fall relative to demolition prices these figures rise to 1.9%, 12% and 21% respectively for age groups 3,4,5. On the other hand at the peak of the boom the estimated scrapping falls down to 0.2%, 1.4% and 3.2% respectively.

Equation $(\hat{8})$ is the empirical supply of tanker orders. The estimates imply that supply of tankers rises when tanker prices increase. On the other hand there is a strong and statistically significant negative effect of dry cargo prices on the supply of tankers. This is because shipbuilders are expected to supply more dry cargo ships when their values rise, at the expense of tankers. Current deliveries of tankers have a negative effect since they directly reduce the stock of ships on order. On the other hand an expansion of shipbuilding capacity *CP* is expected to have a positive influence on the supply of ships. Equation $(\hat{9})$ is the empirical version of (9). It relates deliveries to lagged orders. According to the estimates a 10% increase in the order book leads to 5.2% increase in deliveries in the following year. The lagged dry cargo order book was also included in the regression and it was found to have a negative effect on tanker deliveries. This possibly reflects the fact that as the dry cargo order book expands, shipbuilders divert some of their capacity towards fulfilment of these orders at the expense of tanker deliveries. Shipbuilding capacity was found to have a positive effect since, for a given order book a larger capacity implies fewer orders per shipyard which allows for the order book to be depleted at a faster rate. On the other hand a lower capacity implies that delivery has to be postponed in the future.

Equation $(\widehat{10})$ relates current newbuilding prices to future expected tanker prices. These two are equal up to a constant which reflects risk premia and vintage effects. Because our indices are arbitrarily and independently based the constant will change depending on the base of the indices and so it no longer has an economic interpretation.

5.4 Simulations

In this chapter the response of the tanker market to various shocks in the exogenous variables is simulated. In chapter 3 the dynamic response of the theoretical model to various anticipated and unanticipated shocks was analysed by means of phase diagrams. The structure of the theoretical model is very similar to that of the econometric model of the tanker market estimated above. Thus similar qualitative results are expected. However, there are also some peculiar features in the results presented here. These reflect some structural differences between the theoretical and empirical model. In particular, unlike the theoretical model, the empirical version does not assume instantaneous delivery while in addition it takes into account the ageing process.

The simulation method used is the same as for the dry cargo model which is discussed in more detail in section 4.4. Thus the model is simulated over a period of 35 years even though we only report the results for the first 12 years. This is because in the case of a rational expectations model, the final years of the simulations are distorted by the terminal conditions. Our terminal conditions assume that at the terminal period the model's endogenous variables grow at a constant rate. Because the model is non-linear the results are necessarily state dependent. We have chosen a base run set where extreme values of the exogenous variables have been intentionally removed in order not to distort the results. To carry out an unanticipated shock the change in the external factor is introduced in the first year of the simulation whereas in the case of an anticipated shock the change is introduced in the fourth year of the simulation and the market is allowed to speculate on the basis of it from the first year onwards.

5.4.1 Demand shocks

Table 5.3 shows the response of the system to a demand shock which permanently raises the level of demand by 10%. The table distinguishes between cases where the shock is anticipated or not. Columns with an "*A*" heading refer to the results of an anticipated shock while those with a "*U*" heading refer to the results of an unanticipated shock.

Unanticipated increase in demand

An unanticipated increase in demand leads to an immediate increase in freight rates of around 26%. This implies an increase of time charter rates of around 28.7%. The expected profit profile improves and thus prices increase by 23.5%. This increase in values is restrained by the fact that the higher prices will increase the growth rate of the fleet which will bring future rates down. Indeed in year 0 scrapping falls by almost half of a percent. Deliveries however are initially unchanged. In the following years shipbuilding begins to respond to the higher values. In year 1 deliveries are up 9% and by year 4 they are up 15.8%. Scrapping drops by 0.87 of a percent in year 3. This also helps to raise the size of the fleet and thus market balance, rates and profits lose some of their initial gains. The declining prices cause a deceleration in the rate of increase of the fleet size and thus in the long run the system makes a soft landing close to the base run level. The shock raises the size of the fleet permanently by an amount which is almost equal to the increase in demand. This causes rates, profits, prices and thus shipbuilding output and scrapping to return to the base run level.

Anticipated increase in demand

When the shock is anticipated there is a 4% speculative increase in ship values in year 0 when the

Table 5.3

SIMULATED EFFECTS OF A 10% INCREASE IN THE LEVEL OF TANKER DEMAND[2]

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.2	29.7	-0.1	26.0	0.00	-1.10	4.0	23.5
1	-0.8	23.3	-0.7	20.1	0.04	-0.91	6.3	18.7
2	-2.3	19.9	-2.0	17.1	0.08	-0.62	10.7	14.5
3	-5.0	15.3	-4.4	13.4	0.16	-0.43	19.2	12.1
4	23.4	11.9	20.1	10.5	-0.27	-0.30	14.7	9.9
5	17.8	10.0	15.3	8.4	-0.33	-0.22	11.4	8.0
6	13.7	8.7	11.7	6.3	-0.25	-0.18	9.0	6.6
7	10.5	6.0	8.9	5.5	-0.19	-0.14	7.2	5.3
8	8.1	5.3	6.8	4.7	-0.15	-0.12	5.9	4.5
9	6.3	4.2	5.3	3.8	-0.11	-0.10	4.9	4.0
10	5.0	3.8	4.2	3.4	-0.08	-0.09	4.2	3.4
11	4.1	3.3	3.5	2.8	-0.06	-0.07	3.6	3.0
12	3.4	2.7	3.0	2.5	-0.05	-0.06	3.1	2.7

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.1	0.2	0.0	0.0	-0.12	-0.48
1	0.3	1.2	3.5	9.0	-0.29	-0.82
2	0.8	2.3	9.8	14.3	-0.49	-0.87
3	1.8	3.3	20.2	15.8	-0.80	-0.80
4	3.2	4.3	26.4	14.9	-0.95	-0.70
5	4.7	5.0	27.1	13.5	-0.79	-0.62
6	6.1	5.8	24.3	11.7	-0.64	-0.57
7	7.1	6.3	20.2	10.0	-0.51	-0.41
8	8.0	6.9	16.3	9.2	-0.44	-0.37
9	8.7	7.1	13.2	8.4	-0.39	-0.34
10	9.2	7.6	10.9	8.0	-0.34	-0.32
11	9.5	7.7	9.2	7.0	-0.29	-0.29
12	9.8	7.8	8.0	6.4	-0.26	-0.27

[2] percentage changes.

Lay-up, Scrapping: changes in percentage points.

news regarding the future higher level of demand come out. This causes an immediate reduction in scrapping that raises the size of the fleet and so rates go down initially. Prices continue to increase in the next few years until they reach an all time high of 19.2% up just before the actual increase in demand occurs in year 4. In the meantime the higher prices continuously reduce scrappings and also cause an increase in deliveries except for year 0 where the increase in prices is unanticipated and shipbuilding is predetermined. These increases in the fleet are accumulated so that in year 3, just before the increase in demand materializes, rates are at an all time low. In the next year demand increases and this will completely cancel the negative effects of the speculative increase in the fleet. Thus freight rates increase by 20.1% in year 4. From then on prices begin to fall towards the base run level. As long as prices remain above the base run level the fleet continues to expand. This causes a parallel reduction in prices and rates until in the end the fleet expands almost as much as demand. Thus rates, profits, prices and fleet growth rate return close to the base run level.

5.4.2 Bunker price shocks

This section considers the impact of changes in bunker prices on the tanker market. The results are shown on Table 5.4. It can be seen that an increase in fuel prices leads to a strengthening of tanker prices and rates. On the contrary, the oil price increases of the seventies were followed by a significant depression. This is only because the historical increase in oil prices coincided with significant drops in demand, as the price increase was engineered by cutbacks in the long haul OPEC exports. The negative effects of the big drop in demand cancelled out the positive effects of the higher oil price and thus the market became depressed. The

Table 5.4

SIMULATED EFFECTS OF A 100% INCREASE IN BUNKER PRICES[3]

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.3	71.0	-0.3	72.0	0.02	-1.92	8.3	56.7
1	-1.7	64.4	-1.5	66.5	0.07	-1.20	12.8	44.0
2	-4.6	52.8	-4.0	56.2	0.17	-0.85	21.8	33.2
3	-9.5	41.0	-8.3	45.7	0.34	-0.59	40.0	24.9
4	50.0	30.9	53.9	36.6	-0.52	-0.41	30.0	18.8
5	38.1	23.1	43.2	29.5	-0.41	-0.27	22.5	14.5
6	28.6	17.5	34.7	24.4	-0.31	-0.17	17.0	11.5
7	21.7	13.8	28.5	21.1	-0.22	-0.10	13.2	9.5
8	16.9	11.4	24.1	18.9	-0.15	-0.05	10.7	8.2
9	13.7	9.8	21.1	17.6	-0.09	-0.02	8.9	7.3
10	11.6	8.9	19.1	16.7	-0.05	0.00	7.9	6.8
11	10.3	8.4	17.8	16.1	-0.02	0.01	7.3	6.6
12	9.5	8.1	16.9	15.8	-0.01	0.02	7.1	6.5

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.1	0.6	0.0	0.0	-0.25	-1.34
1	0.6	2.6	7.4	23.6	-0.56	-1.98
2	1.7	5.3	20.6	46.4	-0.91	-1.91
3	3.6	8.3	43.8	56.2	-1.41	-1.67
4	6.3	11.1	58.3	53.7	-1.63	-1.40
5	9.3	13.5	59.3	44.9	-1.36	-1.11
6	11.9	15.3	51.4	35.3	-1.11	-0.85
7	14.0	16.7	40.8	27.1	-0.89	-0.65
8	15.6	17.6	31.1	21.1	-0.76	-0.55
9	16.8	18.2	23.6	16.9	-0.70	-0.51
10	17.7	18.7	18.4	14.2	-0.62	-0.47
11	18.4	19.1	15.0	12.5	-0.55	-0.42
12	18.9	19.3	12.9	11.6	-0.50	-0.39

[3] percentage changes.

Lay-up, Scrapping: changes in percentage points simulations performed here aim to isolate purely the effects of the oil price change itself. Thus, as with other exogenous variables, the level of demand is assumed to be unchanged after the increase in fuel prices.

A change in the bunker price affects only the supply of tanker freight services. Because supply shifts back, an increase in the price of bunkers will imply an increase in freight rates as well, unless demand is completely elastic in which case rates do not change. The magnitude of the increase in rates depends on the elasticity of demand. This has been assumed to be completely inelastic.

In order to analyse theoretically the impact effects on rates of a change in bunker prices let us take the case where fuel is the only variable input of production. This is not an unrealistic situation since, apart form port services fuel is indeed the only variable input. In this hypothetical case supply depends on the ratio of freight rates to bunker prices. Because demand is actually considered to be completely inelastic the increase in fuel price leaves the equilibrium real freight rate unchanged. At equilibrium, rates must increase in proportion to bunker prices so that they completely cancel the negative effects of the higher price of fuel to bring forward the amount of supply required to satisfy the exogenous level of demand. Since rates increase by the same proportion as fuel prices, then so do time charter rates. Thus, when demand is inelastic, an increase in bunker prices leads, through its impact on rates, to an increase in profitability and consequently prices.

Because the freight market affects the ship markets only through changes in profitability, while at the same time bunker prices do not directly affect the ship markets, an increase in bunker prices implies very similar changes in the second hand, shipbuilding and scrapping markets as an increase in demand does.

Unanticipated increase in bunker prices

Table 5.4 shows the response of the markets to a doubling in the price of fuel. In year 0 freight and time charter rates increase by over 70% for reasons already explained above. The freight market boom is expected to last for some time since the increase in bunker prices is permanent while the response of the fleet to the higher profits cannot be immediate. There is thus a 56.7% initial speculative increase in prices caused by the increase in the short term profitability and the anticipated improvement over the longer term future. The increase in prices causes an immediate reduction in the scrapping rate of about 1.34%. In the following years shipbuilding also responds and deliveries increase. Shipbuilding peaks at year 3 when deliveries increase by 53.7%. Thus the fleet continuously increases and this implies that rates are continuously receding from year 0 onwards. In anticipation prices are also losing some of the initial gains. This is until the fleet rises by about 19% in the long run so that it brings time charter rates, profits, prices and fleet growth down towards the base run level. In the long run, freight rates are estimated to be around 15% higher. This is in order to cancel the negative effects of the permanent rise in costs so that profits and prices remain in the long run close to the base run level. This is required in order for the fleet to grow in line with demand.

Anticipated increase in bunker prices

When the shock is anticipated the market foresees its positive impact on profitability and so prices increase before the shock. This considerably reduces the impact of the shock on profits as the fleet also responds to the rise in values. In year 1 deliveries are up 7.4%, 20.6% in year 2 and 43.8% in year 3. Scrapping drops immediately by 0.25%, 0.56% in year 1, 0.91% in year 2 and 1.41% in year 3. The net result of these changes is that by the time the shock occurs the fleet has already increased by 6.3%. Thus in year 4 rates increase by only 50% whereas when the shock is unanticipated and the fleet cannot respond the maximum increase is about 70%. Prices reach an all time high (40% up) at the end of year 3 and this is lower than the 56.7% peak in the case of the unexpected shock. From year 4 onwards prices begin to fall towards the base run value as the fleet continues to expand because of the high ship values. This is until the fleet grows by about 19% which sends rates, profits and prices back to the base run level and the growth rate of the fleet moves in line with that of demand. There are similar long run changes as in the unanticipated scenario. Thus freight rates are 16.9% higher in the long run.

5.4.3 Shipbuilding Cost Shock

This section considers the effect of an increase in shipbuilding costs on the tanker market. The results are shown on Table 5.5. The direct effect of the shock is to reduce the supply of new tankers at a given level of ship prices. This restrains the growth rate of the fleet and causes an increase in rates and values.

Unanticipated increase in shipbuilding costs

When the shock is unanticipated deliveries begin to drop from year 1 onwards. In anticipation of this, values increase in year 0 and this reduces scrapping. The drop in deliveries is however bigger than the drop in scrapping and so the fleet falls. In year 0 where deliveries are predetermined the fleet actually rises because of the immediate drop in scrappings and so rates fall. The magnitude of these short term changes are very small however. From year 1 onwards net investment drops and the fleet begins to fall by an increasing amount. This process continues so there are further improvements in rates and prices. Eventually the fleet drops by 2.4%.

Table 5.5

SIMULATED EFFECTS OF A 50% INCREASE IN SHIPBUILDING COSTS[4]

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	0.0	-0.1	0.0	-0.1	0.00	0.01	0.5	2.9
1	-0.1	0.2	-0.1	0.2	0.00	0.00	0.6	3.8
2	-0.3	1.1	-0.2	1.0	0.01	-0.03	0.8	4.6
3	-0.6	2.0	-0.5	1.8	0.02	-0.06	1.2	5.2
4	-1.0	2.7	-0.8	2.5	0.03	-0.07	2.2	5.7
5	-0.8	3.3	-0.6	3.0	0.02	-0.08	3.5	6.2
6	0.4	3.9	0.5	3.5	0.00	-0.09	4.7	6.8
7	1.8	4.4	1.8	4.0	-0.03	-0.09	5.9	7.4
8	3.2	5.0	2.9	4.4	-0.06	-0.09	6.8	8.0
9	4.3	5.6	3.9	4.9	-0.07	-0.09	7.6	8.6
10	5.2	6.3	4.6	5.4	-0.08	-0.09	8.3	9.2
11	6.0	6.9	5.1	5.8	-0.08	-0.10	8.8	9.8
12	6.6	7.5	5.6	6.2	-0.09	-0.10	9.5	10.4

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.0	0.0	0.0	0.0	-0.02	-0.09
1	0.0	-0.1	0.4	-19.2	-0.03	-0.15
2	0.1	-0.4	1.0	-23.4	-0.05	-0.20
3	0.2	-0.7	1.7	-22.2	-0.07	-0.23
4	0.3	-1.0	2.8	-19.4	-0.12	-0.25
5	0.2	-1.2	-17.6	-16.8	-0.13	-0.24
6	-0.2	-1.4	-22.5	-14.8	-0.16	-0.23
7	-0.7	-1.5	-21.7	-13.4	-0.17	-0.20
8	-1.1	-1.7	-18.9	-12.3	-0.18	-0.17
9	-1.5	-1.9	-15.9	-11.6	-0.18	-0.14
10	-1.8	-2.1	-13.5	-10.8	-0.17	-0.13
11	-2.0	-2.2	-11.9	-10.0	-0.16	-0.12
12	-2.1	-2.4	-10.6	-9.2	-0.15	-0.11

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[4] percentage changes.

Lay-up, Scrapping: changes in percentage points

This causes freight rates to increase by 6.2% and the implied increase in profitability leads to a 10.4% increase in prices. This is sufficient in order to cancel the negative effects of the increase in the shipbuilding costs on the growth rate of the fleet. Fleet growth returns to to the base run level and the system settles at a new long run equilibrium. There, the fleet is permanently lower and consequently rates and prices are higher. Scrapping is also permanently reduced.

Anticipated increase in shipbuilding costs

If the shock is anticipated the fleet actually increases in the first few years before the actual increase in costs takes place. The market anticipates the improvement in profits and there is thus an initial speculative jump in values. Because costs have not risen yet, shipbuilding initially expands. This causes a drop in rates. When the shock actually occurs deliveries begin to drop significantly and this causes the fleet to fall below the base run level from year 6 onwards. The reductions in net investment are accumulated and the fleet continues to fall. Eventually the fleet falls by 2.1% and rates increase by about 6%. Prices rise by about 10%. This cancels the negative effects of the higher costs on the fleet growth.

CHAPTER 6

INTEGRATED MODEL OF THE SHIPPING MARKETS

This chapter links the individual dry cargo and tanker models estimated in the previous chapters. The model is closed by modelling the behaviour of the combi fleet and the demand for scrap. The integration of the two sectors allows us to simulate the spillover effects from the one sector to the other.

6.1 Introduction

In this chapter, the dry cargo and tanker models previously estimated are linked together in order to develop an integrated model of the shipping markets. The integrated model mainly consists of the equations estimated in chapters 4, 5 as reported in tables 4.2 and 5.2. However in order to close the model the evolution and trading behaviour of the combi fleet has to be endogenised by specifying a new set of equations. The integration of the two sectors allows us to endogenise the price of scrap as well by adding a demand for ship scrap to the supply side of the scrap market estimated in previous chapters.

The modelling of each of the major shipping sectors in isolation, has prevented the treatment of the behaviour and evolution of the combi fleet in an endogenous fashion. The combi sector is affected by events in both the dry cargo and tanker markets. For example, the proportion of combis trading in dry, depends on dry cargo relative to tanker rates. The scrap price has also been treated as exogenous. This is again because the equilibrium scrap price depends on what happens in both sectors. In turn, this is due to the fact that the total supply of ships for scrap is that generated by both the dry cargo and tanker fleet.

Like the single ship type models, the integrated model can be simulated in order to determine the impact of exogenous shocks on the path of the system. The integration allows us to investigate the spillover effects from one sector to the other. Thus the effects of changes in the dry cargo demand onto the tanker market and vice versa can be analysed.

There are three main links between the dry cargo and tanker sectors that lead to the spillover effects. The first one is a freight market link and this arises because of the existence of combis. The combined carriers are versatile ships which can switch between the tanker and dry bulk markets. This decision will obviously depend on the relative profitability of the two sectors. Because of this link a shock which tends to tighten the dry cargo freight market say, will tend to spillover onto the tanker sector. The higher dry cargo rates will attract combis from the tanker market, reducing the supply there, which will consequently cause tanker rates to increase as well.

The second link works through the supply side of the shipbuilding market. This link arises because of the fact that shipbuilders can switch from the construction of one ship type towards the construction of another. The supply of new dry cargo ships should, among other things, depend on the relative profitability of building various ship types. The latter obviously depends on relative ship prices. Because of this link, a shock that tends to have a positive impact on dry cargo values will spillover to the tanker market as shipyards will tend to divert capacity towards the construction of the more profitable dry cargo newbuildings at the expense of tankers. This will tend to restrain the tanker fleet growth and thus cause a rise in tanker rates and prices as well.

The third link works through the scrap market. It arises because of the fact that the total supply of ships for scrap is the sum of that generated by each ship type. Thus an external shock that has a direct positive impact on the dry cargo sector say, will also tend to spillover onto the tanker industry through the scrap market. The rise in dry cargo values will lead to a withdrawal of dry cargo ships from the scrap market. This will reduce the total supply of ships for scrap and thus scrap prices will tend to increase. In turn this will tend to have a positive effect on the supply of tankers for scrap, thus restraining the growth rate of the tanker fleet that should cause an increase in tanker values and rates as well. Because of these numerous freight, shipbuilding and scrap market links, the two major sectors of the shipping industry are highly interdependent.

Plan of chapter 6

The main parts of the integrated econometric model have been already presented in the previous chapters. Thus section 6.2 focuses on the new aspects of the extended model. These are the behaviour of combined carriers and the determination of scrap prices. A new set of equations is specified which captures these new aspects of behaviour. Section 6.3 presents the econometric estimates of this new set of equations. The dry cargo and tanker sector equations have already been presented in sections 4.3 and 5.3. In section 6.4 the model's response to various anticipated and unanticipated shocks is calculated. The simulated response of each sector to a bunker, shipbuilding cost or an own demand shock is found to be very similar to the one simulated by the individual ship type models of the previous chapters. Thus the emphasis of the discussion is not on the broad features of the simulations which have already been considered, but on the extent to which the existence of the links tend to dumpen or reinforce the response. In addition a new set of results is presented. These are contained in Tables 6.3 and 6.5 which show the response of the tanker market to a dry cargo demand shock and the response of the dry cargo sector to a tanker demand shock.

6.2 Overview

The integrated model mainly consists of equations (1)-(15) of chapter 4 and equations (1)-(15) of chapter 5. There the size of the combi fleet and the proportion of combis in each sector was treated as exogenous. In addition the price of scrap was also treated as exogenous. This section introduces the theoretical ideas which describe the evolution of the combi fleet, its trading pattern as well as the determinants of scrap prices. Here a superscript "'" indicates a tanker variable while a subscript "c" indicates a combi variable. Thus K, K', K_c indicate the dry cargo, tanker and combined carrier fleet respectively.

6.2.1 The trading pattern of the combi fleet

Combis, are versatile ships which can carry either oil or dry bulk goods. They switch from the tanker to the dry cargo freight market in search for higher profits. This suggests that the proportion of combis in oil should depend on the relative profitability of the two freight markets. In turn this reflects relative freight rates and possibly the level of bunker prices. Thus,

$$p_o = F_1(\overset{-}{F}, \overset{+}{F'}, P_b) \tag{1}$$

where

p_o = proportion of combis in oil

In turn the proportion of combis in dry p_d is simply one minus the proportion of combis in oil. Thus,

$$p_d = 1 - p_o \tag{2}$$

6.2.2 The evolution of the combi fleet

In previous chapters it was suggested that the supply of newbuildings of a particular ship type should depend positively on its own price but negatively on the price of alternative types. Thus here, the supply of new combis should depend positively on the price of combis but negatively on the price of tankers and dry cargo ships. In practice it is difficult to operationalize the implied econometric supply function of combi newbuildings. This is not only because data on combi prices is scant. More importantly the equilibrium price of combis is likely to be a weighted average of the price of dry cargo and tanker ships, since a combi is "half a tanker", "half a dry cargo ship." Thus even if good quality data was available it would be difficult to estimate the effect of the various ship prices on the combi supply because of multicollinearity in the data. Instead it is assumed that at equilibrium the combi order book is proportional to a weighted average of dry cargo and tanker orders as well as a function of the premium on combis relative to tankers and dry cargo ships. The size of the combi fleet is quite small so as not to warrant a theoretically fully satisfactory specification of its determinants given the above data problems. Because of its small size, this should make little difference in the results. Thus,

$$Q_c = F_2(\overset{+}{Q}, \overset{+}{Q'}, \overset{-}{K_c/(K+K')}) \tag{3}$$

The final term in the above equation is the size of the combi fleet as a proportion of the tanker and dry cargo fleet. This is used as a proxy for the unobservable premium on combis. This is because the premium on combis should vary inversely with the covariance between tanker and dry cargo profits. In turn this covariance moves in line with the above ratio.

Combi deliveries are assumed to be a function of lagged orders, as in equation (4) below.

$$Dc_t = \sum_{i=1}^{m} Qc_{t-i} \tag{4}$$

The scrapping rate of combis is assumed to be a weighted average of the dry cargo and tanker scrapping rates. Thus,

$$sc = F_3(\overset{+}{s}, \overset{+}{s'}) \tag{5}$$

6.2.3 Demand for Scrap

In order to endogenise the scrap price we add a demand for scrap function. The demand for scrap is assumed to depend negatively on the price of scrap relative to the price of metals. In addition it is also assumed to vary in line with the existing scrapping capacity. Thus,

$$S^d = F_4(P_s/P_m,\ Z) \qquad (6)$$

where

S^d = Demand for scrap

P_m = Price of metals

Z = Scrapping capacity

At equilibrium the demand for scrap should equal to the supply generated by the dry cargo, tanker and combi fleet. Thus,

$$S^d = S + S' + S_c \qquad (7)$$

6.3 Estimation

6.3.1 Econometric Methodology

Equation (1) is estimated by two stage least squares. This is because dry cargo and tanker rates which appear on the RHS of the equation are endogenous. Moreover the link between the disturbance term of this equation and freight rates is immediate and its probably strong. This is because a change in combi trading pattern immediately affects the supply situation in both tanker and dry cargo freight markets and thus the equilibrium rates as well.

This suggests that the endogenous tanker and dry cargo rates that appear in (1) should be instrumented. The instruments uses are the predetermined variables in the freight market sectors that are likely to be relevant for explaining freight rates. These are the level of demand and the fleet size in each of the two sectors as well as fuel prices.

Equation (6) is also estimated by instrumental variables methods. The variable which is instrumented is the endogenous scrap price. The instruments used are predetermined variables of the system which can explain the movements in scrap prices. These are the level of demand, the predetermined fleet size as well as the shipbuilding costs. The exogenous variables of (6) are also included as instruments of themselves as well as of the scrap price.

Equation (4) is estimated by OLS since all the variables on the RHS are predetermined. Equation (3) is also estimated by OLS since the historical movements in dry cargo and tanker orders largely reflect own sector specific shocks rather than movements in the disturbance term of (3). In addition the size of the fleets which are used as proxies of the premium are also predetermined and thus do not have to be instrumented. Equation (5) is also estimated by OLS since the historical movements in tanker and dry cargo scrapping largely reflect own sector specific shocks rather than the minimal influence of the disturbance term.

6.3.2 Results

The econometric estimates of the above equations are shown on Table 6.1. Equation $(\hat{1})$ is the empirical version of equation (1). A logistic specification has been used. A lagged dependent variable was found to be significant and this possibly reflects costs of moving from one sector to the other. It can be seen that an increase in tanker rates increases the proportion of combis in oil.

Table 6.1 Econometric Estimates[1]

$$\ln(p_o/(1-p_o)) = -6.32 + 0.58\ln(p_o/(1-p_o))_{-1}$$
$$\qquad (2.64) \quad (3.02)$$

$$+ 2.99\ln(F'/Pb) - 1.62\ln(F/Pb) + 1.54SIZE - 1.73DUM_1 \qquad (\hat{1})$$
$$(4.62) \qquad (-2.98) \qquad (2.44) \qquad (-3.20)$$

$\bar{R}^2 = 0.876$, $S.E = 0.45$, $D.W = 1.82$

$$\ln Qc = -1.32 + 0.89\ln Qc_{-1} - 0.35\ln Dc$$
$$(-1.80) \quad (4.99) \qquad (-2.40)$$

$$+ 0.28\ln Q' + 0.45\ln Q - 12.42(Kc/(K+K')) \qquad (\hat{3})$$
$$(2.37) \qquad (1.77) \qquad (-4.05)$$

$\bar{R}^2 = 0.913$, $S.E = 0.24$, $D.W = 1.43$

$$\ln Dc = -0.44 + 0.38\ln Dc_{-1} + 0.25\ln Qc_{-1} + 0.86\ln Qc_{-2}$$
$$(-2.00) \quad (2.44) \qquad (1.41) \qquad (3.10)$$

$$- 0.59\ln Qc_{-3} - 0.96DUM_4 \qquad (\hat{4})$$
$$(-3.21) \qquad (-3.52)$$

$\bar{R}^2 = 0.915$, $S.E = 0.26$, $D.W = 2.21$

$$sc = -0.02 + 1.36s + 0.47s' \qquad (\hat{5})$$
$$(-2.07) \quad (3.52) \quad (2.25)$$

$\bar{R}^2 = 0.779$, $S.E = 0.014$, $D.W = 1.99$

$$S = -5.22 + 0.70S_{-1} - 1.49\ln(Ps/Pm) + 1.30\ln Z \qquad (\hat{6})$$
$$(-3.14) \quad (4.59) \quad (-2.89) \qquad (3.30)$$

$\bar{R}^2 = 0.816$, $S.E. = 0.306$, $D.W. = 1.532$

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[1] Figures in parentheses are t-statistics for testing the hypothesis that the true value of the coefficient is equal to 0.

On the other hand an increase in dry cargo rates leads to a withdrawal of combis from the tanker market. A dummy variable was also included in the regression. This takes the value of 1 in year 1970. The average size of the combi fleet was also included as an additional regressor and was found to have a significant positive effect as expected. This is because large combis are more suitable for oil transportation rather than dry.

Equation $(\hat{6})$ is the empirical version of the aggregate demand for ship scrap. It can be seen that the elasticity of demand with respect to scrap prices is estimated to be equal to -1.49. The coefficient on capacity was also found to be positive as expected.

Equation $(\hat{3})$ is the estimated version of the supply of new combined carriers. The coefficient on tanker and dry cargo order book was found to be positive. On the other hand the coefficient on the proxy for the premium was found to be significantly negative as expected. A dynamic version of the equation was found to give the best fit.

Equation $(\hat{4})$ is the empirical version of equation (4) which relates deliveries on lagged orders. The coefficients indicate that in the long run deliveries are almost exactly proportional to orders.

Finally, equation $(\hat{5})$ is the empirical version of equation (5). It relates the proportion of combis scrapped to the aggregate tanker and dry cargo scrapping rates. It is found that an increase in either tanker or dry cargo scrapping is associated with an increase in combi scrapping as well.

6.4 Simulations

This section presents simulations of the integrated model which show how the system responds to various external shocks. The results are similar to the ones presented in previous chapters so here the emphasis is on how the links affect the simulations rather than on the broad patterns themselves. In addition the integration allows us to consider the impact of changes in the level of dry cargo demand on the tanker market and vice versa. Such an analysis has up to here been prevented by the modelling of each sector in isolation.

6.4.1 Dry Cargo Demand Shocks

Impact on the dry cargo market

Table 6.2 shows the effects of permanent changes in the level of dry cargo demand on the dry cargo market. These results are similar to those shown on Table 4.2 of chapter 4 where the impact of demand shocks was analysed by simulating the dry cargo model. As in the case of Table 4.2, rates, prices, shipbuilding and scrapping initially overshoot their long run equilibrium level. Comparing the two tables it can be seen that in the short term the impact of the shock on rates, prices and the fleet is smaller in this case where the two sectors have been linked.

In the longer term however the impact on rates and prices is stronger here than that shown on Table 4.2. This is because of the differing speeds of reaction of the combi and shipbuilding links. The combi link works immediately while the response of the fleet takes more time to have an accumulated impact.

In the short term the higher dry cargo demand leads to an increase in rates. As can be seen from Table 6.2 this attracts more combis to the dry cargo market. This in turn cushions the impact effect of the increase in demand on dry cargo rates. Thus the short term impact of the shock on rates is smaller here than in the case of the single ship type model.

Over time however the shipbuilding link begins to work. The withdrawal of combis from the dry cargo market tends to strengthen tanker values. In addition the higher dry cargo prices also tend to expand the supply of new

Table 6.2

SIMULATED EFFECTS OF A 10% INCREASE IN THE LEVEL OF DRY CARGO DEMAND[2]

IMPACT ON THE DRY CARGO MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.1	39.0	-0.2	30.5	0.01	-1.18	8.8	40.6
1	-1.0	33.6	-0.8	26.2	0.05	-1.03	12.4	31.7
2	-2.7	27.2	-2.1	21.4	0.13	-0.88	19.0	24.3
3	-5.4	20.9	-4.2	16.7	0.27	-0.76	31.2	18.7
4	29.0	15.9	22.9	12.8	-0.62	-0.67	23.1	14.5
5	21.3	12.2	17.1	10.0	-0.56	-0.58	17.3	11.4
6	15.8	9.6	12.9	8.0	-0.50	-0.51	13.2	9.3
7	12.1	7.8	10.0	6.7	-0.45	-0.45	10.4	7.8
8	9.7	6.8	8.2	5.8	-0.40	-0.40	8.5	6.8
9	8.2	6.1	6.9	5.3	-0.37	-0.36	7.1	6.0
10	7.1	5.6	5.9	4.9	-0.34	-0.33	6.2	5.6
11	6.3	5.3	5.2	4.5	-0.30	-0.29	5.7	5.4
12	5.7	5.0	4.6	4.2	-0.27	-0.26	5.6	5.4

Year	Fleet		Deliveries		Scrapping (%)		Combis in oil (%)	
	A	U	A	U	A	U	A	U
0	0.0	0.2	0.0	0.0	-0.12	-0.50	0.0	-7.1
1	0.3	1.0	3.8	8.9	-0.25	-0.78	0.2	-10.6
2	0.8	2.2	9.2	15.5	-0.39	-0.82	0.7	-12.1
3	1.7	3.4	16.2	16.0	-0.56	-0.75	1.7	-12.4
4	2.9	4.5	18.3	13.1	-0.68	-0.67	-3.9	-12.0
5	4.1	5.5	15.5	9.5	-0.74	-0.66	-6.4	-11.1
6	5.2	6.2	11.2	6.7	-0.69	-0.57	-7.1	-9.9
7	6.0	6.7	7.6	4.9	-0.63	-0.50	-6.8	-8.6
8	6.6	7.1	5.2	3.9	-0.53	-0.40	-6.1	-7.5
9	7.1	7.4	3.8	3.4	-0.48	-0.36	-5.3	-6.6
10	7.4	7.6	3.1	3.0	-0.47	-0.37	-4.6	-5.8
11	7.7	7.8	2.7	2.8	-0.44	-0.35	-3.9	-5.1
12	8.0	8.0	2.6	2.7	-0.40	-0.33	-3.4	-4.5

[2] percentage changes.

Lay-up, Scrapping, Combis : changes in percentage points.

dry cargo ships at the expense of tankers. This also has a positive impact on tanker values. In table 4.2 the tanker price is exogenised while here it is allowed to increase following the shock. This increase in tanker prices tends to hold back the expansion of the dry cargo fleet to a level lower than that in table 4.2 where tanker prices are exogenised at the lower base run level. Overtime, this restrain in the dry cargo fleet growth cancels out the influx of combis and thus rates increase by 4.2% in the long run against a figure of 3.0% in Table 4.2.

These differences are reflected on the long run level of time charter rates and prices as well. The restrain in shipbuilding causes the fleet to increase by 8.0% in year 12 whereas in Table 4.2 the fleet increase is 9.2%.

Impact on tanker market

Table 6.3 shows the effect of the higher dry cargo demand on the tanker market. The higher dry cargo demand leads to a withdrawal of combis from the tanker market. As a result tanker freight rates increase. In addition the strong dry cargo values restrain the increase in the tanker fleet as builders switch towards the construction of dry cargo newbuildings. Finally the scrapping market also contributes to a reduction in the tanker fleet. The withdrawal of dry cargo ships from the scrap market reduces the supply of ships for scrap. This raises the equilibrium scrap price. The latter attracts more tankers for scrapping and this helps to reduce the tanker fleet.

When the shock is anticipated the combi fleet moves in an opposite direction initially and thus tanker rates drop. This opposite movement is due to the fact that the shock produces a strong speculative build up of the dry cargo fleet which sends combis away from the dry cargo market to the tanker market which also becomes depressed. When finally the shock occures, the higher dry cargo rates attract the combis back to the dry market so the tanker market also improves.

Table 6.3

SIMULATED EFFECTS OF A 10% INCREASE IN THE LEVEL OF DRY CARGO DEMAND[3]

IMPACT ON THE TANKER MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	0.0	2.6	0.0	2.3	0.00	-0.15	1.9	6.8
1	-0.1	4.1	-0.1	3.6	0.00	-0.20	2.8	7.1
2	-0.3	4.9	-0.3	4.3	0.01	-0.18	4.0	7.0
3	-0.5	5.4	-0.5	4.7	0.02	-0.16	5.8	6.6
4	2.5	5.5	2.2	4.8	-0.04	-0.14	6.5	5.8
5	4.4	5.3	3.8	4.6	-0.09	-0.12	6.4	5.0
6	5.2	4.7	4.6	4.2	-0.10	-0.10	5.9	4.2
7	5.3	4.1	4.7	3.6	-0.10	-0.09	5.1	3.5
8	4.9	3.4	4.4	3.1	-0.10	-0.07	4.3	2.9
9	4.3	2.8	3.9	2.6	-0.08	-0.06	3.6	2.5
10	3.7	2.4	3.4	2.3	-0.07	-0.05	3.0	2.2
11	3.1	2.1	3.0	2.0	-0.06	-0.04	2.6	2.0
12	2.7	1.9	2.6	1.9	-0.05	-0.03	2.2	1.9

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.0	0.0	0.0	0.0	-0.01	0.00
1	0.0	0.0	0.0	0.1	-0.03	-0.06
2	0.0	0.0	-3.9	-7.5	-0.04	-0.12
3	-0.1	0.0	-9.0	-11.5	-0.05	-0.18
4	-0.3	-0.1	-14.0	-11.5	-0.08	-0.20
5	-0.6	-0.2	-14.4	-9.5	-0.11	-0.16
6	-0.8	-0.3	-11.9	-7.1	-0.13	-0.14
7	-1.0	-0.4	-8.5	-5.3	-0.13	-0.11
8	-1.0	-0.4	-5.7	-4.1	-0.11	-0.08
9	-1.1	-0.4	-3.7	-3.3	-0.07	-0.04
10	-1.1	-0.5	-2.6	-2.8	0.01	0.00
11	-1.1	-0.6	-2.0	-2.5	0.01	0.02
12	-1.2	-0.7	-1.7	-2.3	0.01	0.04

[3] percentage changes.

Lay-up, Scrapping: changes in percentage points.

6.4.2 Tanker Demand Shocks

Impact on tanker market

Table 6.4 shows the impact of a permanent increase in the level of tanker demand on the equilibrium time path of the tanker market. This can be compared with the results shown on Table 5.2 were the impact of such a shock was analysed by simulating the tanker model in isolation. Again here the short term overshooting of rates, prices, shipbuilding and scrapping is evident.

The integrated model simulates a lower short term response of rates and prices than the isolated tanker model. At the same time, here, the simulated long term response is higher than in Table 5.2. This again reflects the differing speed and magnitude of reaction of the combi and shipbuilding link. The combi link works immediately. The higher tanker demand attracts combis into the tanker market which cushion the positive impact of the shock.

Over the longer term the increase in the fleet size is lower than in Table 5.2. This is because of the fact that here the dry cargo newbuilding price has also been allowed to respond positively to the shock. This higher dry cargo price restrains the expansion of the tanker fleet to a lower level than that shown by Table 5.2. This cancels out the depressing effect of the influx of combis and thus long run rates are higher here.

Impact on dry cargo market

The higher tanker demand has positive implications about the equilibrium level of dry cargo rates and prices as well. Both the combi, shipbuilding and scrapping links contribute towards this improvement. The higher tanker demand attracts combis away from the dry cargo freight market which consequently improves immediately. The higher tanker prices lead to a higher supply of new tankers at the expense of dry cargo newbuildings. Thus the growth rate of the dry cargo fleet is restrained which further strengthens the dry cargo market. The

Table 6.4

SIMULATED EFFECTS OF A 10% INCREASE IN THE LEVEL OF TANKER DEMAND[4]

IMPACT ON TANKER MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.1	27.4	-0.1	23.4	0.01	-1.05	4.5	20.9
1	-0.7	22.0	-0.6	18.9	0.03	-0.85	6.5	16.5
2	-1.8	17.7	-1.5	15.3	0.06	-0.57	10.2	12.9
3	-3.7	13.9	-3.1	12.1	0.11	-0.39	17.0	10.1
4	21.8	10.9	19.0	9.5	-0.26	-0.27	12.1	8.0
5	15.2	8.5	13.4	7.6	-0.31	-0.19	9.0	6.4
6	11.3	6.8	10.0	6.2	-0.22	-0.15	6.9	5.2
7	8.7	5.6	7.8	5.2	-0.17	-0.12	5.4	4.2
8	7.0	4.8	6.3	4.5	-0.14	-0.10	4.5	3.6
9	5.9	4.1	5.3	4.0	-0.11	-0.08	3.9	3.1
10	5.2	3.7	4.7	3.7	-0.09	-0.07	3.5	2.7
11	4.7	3.5	4.3	3.5	-0.08	-0.06	3.3	2.5
12	4.6	3.4	4.0	3.4	-0.07	-0.06	3.3	2.5

Year	Fleet		Deliveries		Scrapping (%)		Combis in oil (%)	
	A	U	A	U	A	U	A	U
0	0.1	0.2	0.0	0.0	-0.11	-0.44	0.0	8.7
1	0.3	0.9	3.7	8.3	-0.24	-0.75	-0.2	13.8
2	0.7	1.9	9.0	13.3	-0.39	-0.76	-0.8	16.4
3	1.5	2.9	16.9	14.6	-0.61	-0.69	-1.8	17.4
4	2.6	3.8	19.9	13.7	-0.71	-0.60	5.8	17.4
5	3.7	4.6	18.2	12.0	-0.60	-0.49	9.7	16.6
6	4.6	5.3	14.6	10.5	-0.48	-0.40	11.4	15.6
7	5.3	5.8	11.1	9.2	-0.39	-0.31	11.8	14.4
8	5.8	6.2	8.6	8.4	-0.33	-0.26	11.5	13.2
9	6.2	6.5	6.9	7.7	-0.29	-0.24	10.9	11.9
10	6.5	6.8	5.9	7.1	-0.26	-0.21	10.2	10.8
11	6.7	7.0	5.2	6.5	-0.23	-0.18	9.5	9.7
12	6.9	7.1	4.8	6.0	-0.21	-0.16	8.8	8.8

[4] percentage changes.

Lay-up, Scrapping, Combis : changes in percentage points.

Table 6.5

SIMULATED EFFECTS OF A 10% INCREASE IN THE LEVEL OF TANKER DEMAND[5]

IMPACT ON THE DRY CARGO MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	0.0	2.9	0.0	2.3	0.00	-0.16	1.3	7.8
1	-0.2	4.6	-0.1	3.6	0.01	-0.23	1.7	7.2
2	-0.4	5.0	-0.3	4.0	-0.02	-0.24	2.5	5.9
3	-0.9	4.7	-0.7	3.8	-0.04	-0.23	3.9	4.4
4	1.9	4.0	1.6	3.3	0.06	-0.21	4.1	2.9
5	3.1	3.1	2.6	2.6	0.11	-0.18	3.5	1.7
6	3.3	2.2	2.8	2.0	0.13	-0.15	2.6	0.7
7	3.0	1.5	2.5	1.5	0.12	-0.12	1.9	-0.1
8	2.5	1.0	2.1	1.1	0.11	-0.10	1.3	-0.5
9	2.0	0.7	1.7	0.9	0.10	-0.09	0.9	-0.6
10	1.6	0.5	1.3	0.7	0.09	-0.07	0.8	-0.6
11	1.2	0.5	0.9	0.7	0.07	-0.06	0.8	-0.4
12	1.0	0.6	0.7	0.7	0.06	-0.06	0.8	-0.1

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.0	0.0	0.0	0.0	0.00	-0.05
1	0.0	0.1	0.1	1.2	-0.01	-0.10
2	0.0	0.3	-0.1	1.4	-0.01	-0.13
3	0.0	0.4	-0.4	1.3	-0.01	-0.13
4	0.0	0.6	-0.4	0.9	-0.03	-0.12
5	0.1	0.7	0.0	0.4	-0.07	-0.12
6	0.1	0.8	0.3	-0.2	-0.09	-0.09
7	0.2	0.8	0.4	-0.7	-0.10	-0.07
8	0.3	0.8	0.2	-1.1	-0.09	-0.04
9	0.4	0.8	-0.1	-1.4	-0.08	-0.02
10	0.5	0.7	-0.3	-1.5	-0.08	-0.01
11	0.5	0.6	-0.4	-1.4	-0.07	0.00
12	0.5	0.5	-0.4	-1.3	-0.06	0.01

[5] percentage changes.

Lay-up, Scrapping: changes in percentage points.

scrapping link works through the reduction in the supply of tankers for scrap. This reduces the total supply of ships for scrap and raises scrap values. This in turn causes higher scrapping of dry cargo ships the prices of which have not risen as much.

6.4.3 Bunker Price and Shipbuilding Cost Shocks

Tables 6.6 and 6.7 show the impact of bunker shocks on the dry cargo and tanker market respectively. These results can be compared with the results of Tables 4.2 and 5.2. The comparison shows that the existence of various links between the two sectors, makes very little difference to the results. There is again short run overshooting of the long run equilibrium of rates, prices, shipbuilding and scrapping.

Tables 6.8 and 6.9 show the impact of changes in shipbuilding costs on the dry cargo and tanker market respectively. These results can again be compared with those shown on Tables 4.3 and 5.3. The comparison again shows that the existence of various links makes little difference to the results. Rates, prices and scrapping rise to a higher level in the long run. There is again undershooting of the long run level of rates, prices and scrapping. The shock raises the price of both tanker and dry cargo ships. The supply of newbuildings of a particular type is restrained by the increase in the price of the alternative output.

In the single ship type models the price of the alternative output was fixed and this restrain did not operate. This explains why the system rises to a higher level in the long run. In addition the boom in the two sectors mutually reinforce each other because of the scrap market link. The increase in the price of one ship type reduces the supply of scrap and raises the demolition price. This tends to increase the supply for scrap of the other ship type. Again this positive mechanism does not operate in the single ship type models.

Overall we notice that the existence of various freight, shipbuilding and scrapping links, lead to spillover effects from one sector to the other. An increase in the demand for one ship type is, to a smaller extent of course, beneficial for the other sector as well. The links, however, are relatively weak.

Table 6.6

SIMULATED EFFECTS OF A 100% INCREASE IN BUNKER PRICES[6]

IMPACT ON DRY CARGO MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.3	64.7	-0.2	66.8	0.01	-1.08	12.1	66.5
1	-1.3	58.3	-1.1	60.4	0.07	-1.15	18.3	52.4
2	-3.6	48.5	-2.9	52.3	0.19	-1.07	29.6	40.5
3	-7.3	38.5	-6.0	44.0	0.39	-0.99	50.6	30.6
4	48.7	29.7	52.4	36.5	-0.44	-0.94	38.0	22.6
5	37.1	22.2	42.7	30.1	-0.60	-0.88	27.9	16.3
6	27.6	16.2	34.7	24.9	-0.64	-0.82	20.1	11.5
7	20.2	11.6	28.4	20.9	-0.64	-0.76	14.2	8.0
8	14.5	8.1	23.5	17.9	-0.64	-0.72	9.6	5.4
9	10.2	5.5	19.8	15.7	-0.63	-0.69	6.2	3.6
10	6.8	3.6	16.9	14.1	-0.60	-0.65	3.8	2.3
11	4.3	2.2	14.8	12.9	-0.57	-0.61	2.1	1.6
12	2.5	1.3	13.3	12.2	-0.54	-0.57	1.2	1.3

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.1	0.3	0.0	0.0	-0.14	-0.61
1	0.3	1.2	4.2	10.8	-0.29	-0.94
2	0.9	2.6	9.8	16.8	-0.45	-1.01
3	1.9	4.1	17.5	16.6	-0.66	-0.94
4	3.2	5.4	19.3	13.0	-0.81	-0.86
5	4.6	6.5	16.2	8.8	-0.92	-0.86
6	5.9	7.3	11.5	5.2	-0.89	-0.75
7	6.9	7.9	7.1	2.7	-0.82	-0.63
8	7.7	8.3	3.9	1.0	-0.68	-0.48
9	8.2	8.5	1.6	-0.1	-0.59	-0.39
10	8.5	8.5	0.0	-0.8	-0.53	-0.35
11	8.6	8.5	-1.1	-1.3	-0.44	-0.28
12	8.7	8.4	-1.7	-1.5	-0.34	-0.22

[6] percentage changes.

Lay-up, Scrapping: changes in percentage points.

Table 6.7

SIMULATED EFFECTS OF A 100% INCREASE IN BUNKER PRICES[7]

IMPACT ON TANKER MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	-0.3	71.2	-0.3	73.7	0.02	-1.93	12.1	67.8
1	-1.5	68.8	-1.3	70.4	0.07	-1.22	18.6	56.6
2	-4.0	59.8	-3.5	62.5	0.15	-0.88	30.6	47.1
3	-7.9	50.8	-6.8	54.5	0.27	-0.65	53.2	39.1
4	57.4	42.8	60.3	47.3	-0.55	-0.50	44.7	32.8
5	49.0	35.9	52.8	41.1	-0.46	-0.39	37.5	27.7
6	41.5	30.3	46.2	36.0	-0.38	-0.31	31.6	23.7
7	35.1	25.9	40.3	31.9	-0.32	-0.25	26.8	20.6
8	29.7	22.3	35.4	28.5	-0.27	-0.20	22.9	18.1
9	25.2	19.4	31.2	25.8	-0.21	-0.15	19.8	16.2
10	21.5	17.0	27.7	23.5	-0.16	-0.11	17.5	14.8
11	18.5	15.2	24.9	21.7	-0.12	-0.08	15.7	13.7
12	16.2	13.7	22.7	20.3	-0.09	-0.06	14.3	13.0

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.1	0.5	0.0	0.0	-0.24	-1.05
1	0.6	2.1	8.0	22.5	-0.54	-1.67
2	1.5	4.4	15.8	29.0	-0.85	-1.73
3	3.1	6.8	27.4	29.6	-1.27	-1.65
4	5.1	9.0	28.9	28.7	-1.52	-1.54
5	7.3	11.1	28.4	27.8	-1.42	-1.33
6	9.3	12.9	27.9	26.9	-1.28	-1.15
7	11.2	14.5	27.5	26.0	-1.14	-0.98
8	12.9	15.9	27.1	25.3	-1.05	-0.89
9	14.5	17.2	26.6	24.6	-0.99	-0.84
10	15.9	18.3	26.2	24.1	-0.88	-0.75
11	17.2	19.4	25.9	23.7	-0.78	-0.68
12	18.4	20.3	25.5	23.3	-0.71	-0.62

[7] percentage changes.

Lay-up, Scrapping: changes in percentage points.

Table 6.8

SIMULATED EFFECTS OF A 50% INCREASE IN SHIPBUILDING COSTS[8]

IMPACT ON DRY CARGO MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	0.0	-0.1	0.0	-0.1	0.00	0.00	0.8	5.1
1	-0.1	0.0	-0.1	0.0	0.00	0.00	1.1	7.0
2	-0.2	0.9	-0.2	0.7	0.01	-0.04	1.6	9.0
3	-0.5	2.2	-0.4	1.8	0.02	-0.09	2.5	10.9
4	-0.9	3.6	-0.8	2.9	0.04	-0.14	4.0	12.3
5	-0.9	4.8	-0.7	3.8	0.04	-0.18	6.2	13.5
6	0.2	5.8	0.1	4.6	-0.01	-0.21	8.4	14.6
7	1.7	6.6	1.4	5.2	-0.06	-0.24	10.4	15.4
8	3.3	7.3	2.7	5.8	-0.10	-0.26	12.1	16.1
9	4.7	7.9	3.8	6.3	-0.14	-0.27	13.4	16.6
10	5.9	8.4	4.7	6.6	-0.18	-0.28	14.4	17.0
11	6.8	8.7	5.4	6.8	-0.21	-0.28	15.3	17.4
12	7.4	8.9	5.9	7.0	-0.22	-0.28	16.0	17.7

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.0	0.0	0.0	0.0	-0.01	-0.07
1	0.1	0.0	0.3	-8.0	-0.02	-0.11
2	0.1	-0.2	0.6	-12.9	-0.03	-0.14
3	0.2	-0.5	1.1	-14.6	-0.05	-0.17
4	0.2	-0.8	1.8	-14.4	-0.07	-0.21
5	0.2	-1.1	-7.2	-13.6	-0.10	-0.28
6	0.0	-1.2	-12.9	-12.9	-0.13	-0.31
7	-0.4	-1.3	-15.0	-12.3	-0.18	-0.35
8	-0.7	-1.4	-14.7	-12.0	-0.22	-0.36
9	-0.9	-1.4	-14.1	-11.9	-0.27	-0.39
10	-1.1	-1.4	-13.3	-11.9	-0.34	-0.45
11	-1.2	-1.3	-12.8	-11.9	-0.40	-0.48
12	-1.2	-1.2	-12.5	-11.9	-0.44	-0.50

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[8] percentage changes.

Lay-up, Scrapping: changes in percentage points.

Table 6.9

SIMULATED EFFECTS OF A 50% INCREASE IN SHIPBUILDING COSTS[9]

IMPACT ON TANKER MARKET

Year	Time Charter Rate		Freight Rate		Lay-up (%)		Ship prices	
	A	U	A	U	A	U	A	U
0	0.0	-0.1	0.0	-0.1	0.00	0.01	0.6	3.4
1	-0.1	0.2	-0.1	0.1	0.00	0.00	0.9	4.6
2	-0.2	0.9	-0.2	0.8	0.01	-0.03	1.2	5.8
3	-0.5	1.8	-0.4	1.6	0.01	-0.05	1.9	7.1
4	-0.8	2.7	-0.7	2.4	0.02	-0.07	3.0	8.3
5	-0.6	3.7	-0.5	3.3	0.02	-0.08	4.5	9.5
6	0.4	4.8	-0.4	4.2	0.00	-0.09	6.2	10.8
7	1.7	5.8	1.5	5.2	-0.03	-0.11	7.8	12.0
8	3.1	6.9	2.8	6.2	-0.05	-0.12	9.4	13.3
9	4.5	8.1	4.0	7.1	-0.07	-0.12	10.9	14.5
10	6.0	9.3	5.3	8.1	-0.09	-0.13	12.4	15.7
11	7.4	10.4	6.5	9.1	-0.10	-0.13	13.8	16.8
12	8.7	11.5	7.6	10.0	-0.11	-0.14	15.0	17.9

Year	Fleet		Deliveries		Scrapping (%)	
	A	U	A	U	A	U
0	0.0	0.0	0.0	0.0	-0.01	-0.06
1	0.0	-0.1	0.4	-14.9	-0.03	-0.12
2	0.1	-0.3	0.7	-19.6	-0.05	-0.16
3	0.1	-0.6	0.9	-21.0	-0.07	-0.20
4	0.3	-0.9	1.3	-21.3	-0.10	-0.24
5	0.2	-1.2	-15.0	-21.1	-0.13	-0.24
6	-0.2	-1.5	-19.5	-20.6	-0.15	-0.25
7	-0.6	-1.8	-20.4	-19.6	-0.17	-0.24
8	-1.0	-2.2	-20.3	-19.0	-0.18	-0.24
9	-1.5	-2.5	-19.8	-18.1	-0.19	-0.22
10	-1.9	-2.8	-19.0	-17.0	-0.19	-0.20
11	-2.3	-3.1	-17.9	-16.1	-0.19	-0.19
12	-2.6	-3.3	-16.8	-14.8	-0.19	-0.18

[9] percentage changes.

Lay-up, Scrapping: changes in percentage points.

CHAPTER 7

TESTING THE RATIONAL EXPECTATIONS HYPOTHESIS

This chapter tests the assumption of rational expectations in shipping markets. Freight futures, time charter rates and newbuilding prices should reflect expectations of future spot rates, future time charter equivalents and future second hand spot prices respectively.

If in addition expectations are assumed to be rational then testable restrictions are implied about the stochastic process that describes the evolution of these variables. Accordingly, unbiasedness, weak rationality and strong rationality tests are carried out for each set of data. These could be used in order to appraise the validity of the rational expectations hypothesis and the underlying economic theory.

7.1 Introduction

Our theory has assumed that market's expectations of future endogenous variables are 'rational' in the sense of being the same as the mathematical expectations that the structural model generates, conditional on the assumptions regarding the exogenous variables. The rational expectations hypothesis is one of the crucial assumptions and a distinguishing feature of the model since it generates a dynamic behaviour that conventional models cannot replicate.

The rational expectations (R.E) hypothesis has been widely used in theoretical and applied research for various reasons, such as:

1) First, the hypothesis is believed to be more consistent with the fundamental economic axiom of rationality and optimizing behaviour than its predecessors, such as the static or adaptive expectations. The latter are usually ad hoc backward looking forecasting schemes which in general imply biased forecasts.

2) Secondly, models which are based on irrational expectations generating mechanisms can be structurally unstable. This is inspite of the fact that their reduced forms can be observationally equivalent with that of R.E models. The latter implies that both models can simulate just as well the historical experience. However models with irrational expectations mechanisms will tend to break down when the stochastic process that generates the exogenous variables changes. Thus the usefulness of conventional models for forecasting purposes is only limited to a small set of scenarios which involve stochastic fluctuations in the exogenous variables similar to that experienced during the sample period over

which the model has been fitted. For forecasting under an arbitrary set of assumptions the R.E models might be considered to be superior assuming of course that they have been correctly formulated and estimated. This has been emphasized by Lucas (1976) in his critique of econometric policy evaluation.

3) Finally, the hypothesis is manageable and can relatively easily be incorporated into economic models that can be straightforwardly used in order to analyse complex situations.

The R.E hypothesis is now generally considered to be superior to the adaptive and static expectations formulations previously used. It is itself however being critisized for being based on an extreme set of assumptions regarding the economic agents' ability to collect and process information, which are unlikely to hold in the real world. This however turns out to be true for any set of useful scientific assumptions, when closely scrutinized.

Plan of chapter 7

In this chapter the assumption of rational expectations in the shipping markets, is subjected to empirical scrutiny in order to examine the extent to which it can be considered to be consistent with the facts. Our task is to a great extent simplified by the fact that there exist a considerable amount of data which can, according to various theories, be interpreted as direct measurements of expectations of future variables. Using data on these expectations (predictors) and the actual outcomes, the forecast error can be calculated.

Three types of tests are performed. The first is an unbiasedness test were the future outcome is regressed on a constant and on the observable expectation. Under R.E. the estimated constant should not significantly differ from zero while the coefficient on the predictor should be statistically close to one.

The second test is a weak rationality test. This is based on the idea that forecast errors should be statistically uncorrelated with past forecast errors which are part of the information set. This implication can be tested by performing tests on the correlogram of the forecast error. Alternatively a regression of the forecast error on past errors belonging to the information set can be carried out. Then the joint hypothesis that all coefficients are equal to zero can be tested.

The third test is a semi-strong rationality test. If the R.E. hypothesis holds then the forecast error should be uncorrelated with any part of the information set and not just the past errors. Thus in a regression of the forecast error on any subset of variables which belong to the current information test, the hypothesis that all coefficients are equal to zero should not be rejected.

In section 2 data on freight futures is used to examine whether their stochastic properties are consistent with the implications of the R.E hypothesis. In section 3 we do the same with data for long term time charter (rental) rates which should in theory be predictors of a weighted average of actual short term time charter (rental) rates. In section 4 data on newbuilding prices which should reflect expectations of future second hand prices is used. Statistical investigations which test whether the price of the newbuilding is an optimal predictor of the future second hand value of spot ships are performed.

7.2 Freight Futures

The efficient markets hypothesis (EMH) suggests that

$$f_{t,T} = E_t n_T \qquad (1)$$

where

$f_{t,T}$ = futures price in time t for delivery at time T

n_T = spot price at time T

This implies that if expectations are rational then the futures price should follow a random walk.

$$f_{t+1,T} = f_{t,T} + u_{t+1} \tag{2}$$

Moreover the step u_{t+1} should not only be uncorrelated with past futures prices but also with any subset of the current information set. In this section a number of statistical tests are performed which test for the validity of various implications of EMH/RE. Each test is progressively more stringent as the correlation properties of the error term u_t with a progressively enlarged information subset are investigated. The first test investigates whether the futures price follows a random walk by considering the following regression

$$f_{t+1,T} = a + bf_{t,T} + e_{t+1} \tag{3}$$

and testing for $a=0$ and $b=1$ by calculating a Dickey-Fuller (1981) statistic. The second test looks at the error term u_t of (2) and considers whether this is autocorrelated with its past history or not. This can be done by calculating the sample autocorrelation function of u and the associated portmanteau Q-statistics for various lags or by considering the regression

$$u_t = a + \sum_{i=1}^{m} b_i u_{t-i} \tag{4}$$

and testing for $b_i=0$ $(i=1,\dots,m)$ with an F-statistic. The third type of test is a semi-strong rationality test and considers a regression of next period's change in the price of futures on an extended subset of the current information set. This subset includes current and lagged futures and spot prices. Accordingly, we specify the regression equation (5) as follows

$$u_t = a + \sum_{i=1}^{m} b_i f_{t-i,T} + \sum_{i=1}^{m} c_i n_{t-i} \qquad (5)$$

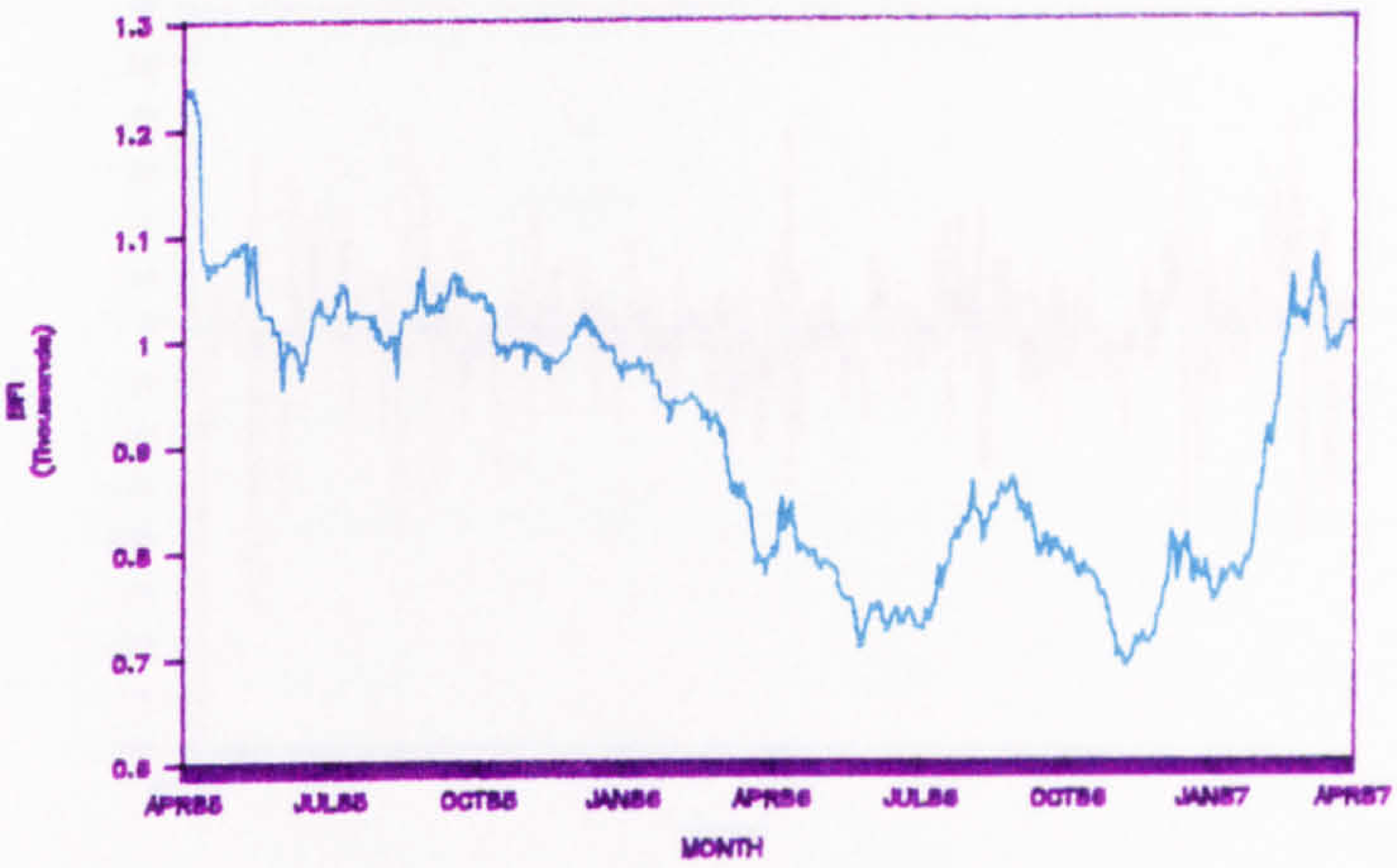
EMH/RE implies that $b_i=0$ $(i=1, \ ,m)$ and $c_i=0$ $(i=1, \ ,m)$. This implication can be tested by calculating a standard F-statistic that tests for the exclusion of these variables.

The daily price movements of the April, July and October 1987 futures contract are separately examined. Each contract has been traded for exactly two years before expiring. Since the index (T) in the notation $f_{t,T}$ does not change as the fluctuations in the price of an individual contract are considered, in what follows, this index is dropped from the notation. Fig. 1 shows the daily fluctuations in the price f_t of the various contracts. According to the theory these should be particular realizations of a random walk process. First differences of these series have been taken in order to calculate the daily *changes* $\Delta f_t = f_t - f_{t-1}$ in the price of the contracts. The resulting series have been plotted on fig. 2. If f_t obeys a random walk process then Δf_t should be a serially uncorellated white noise process.

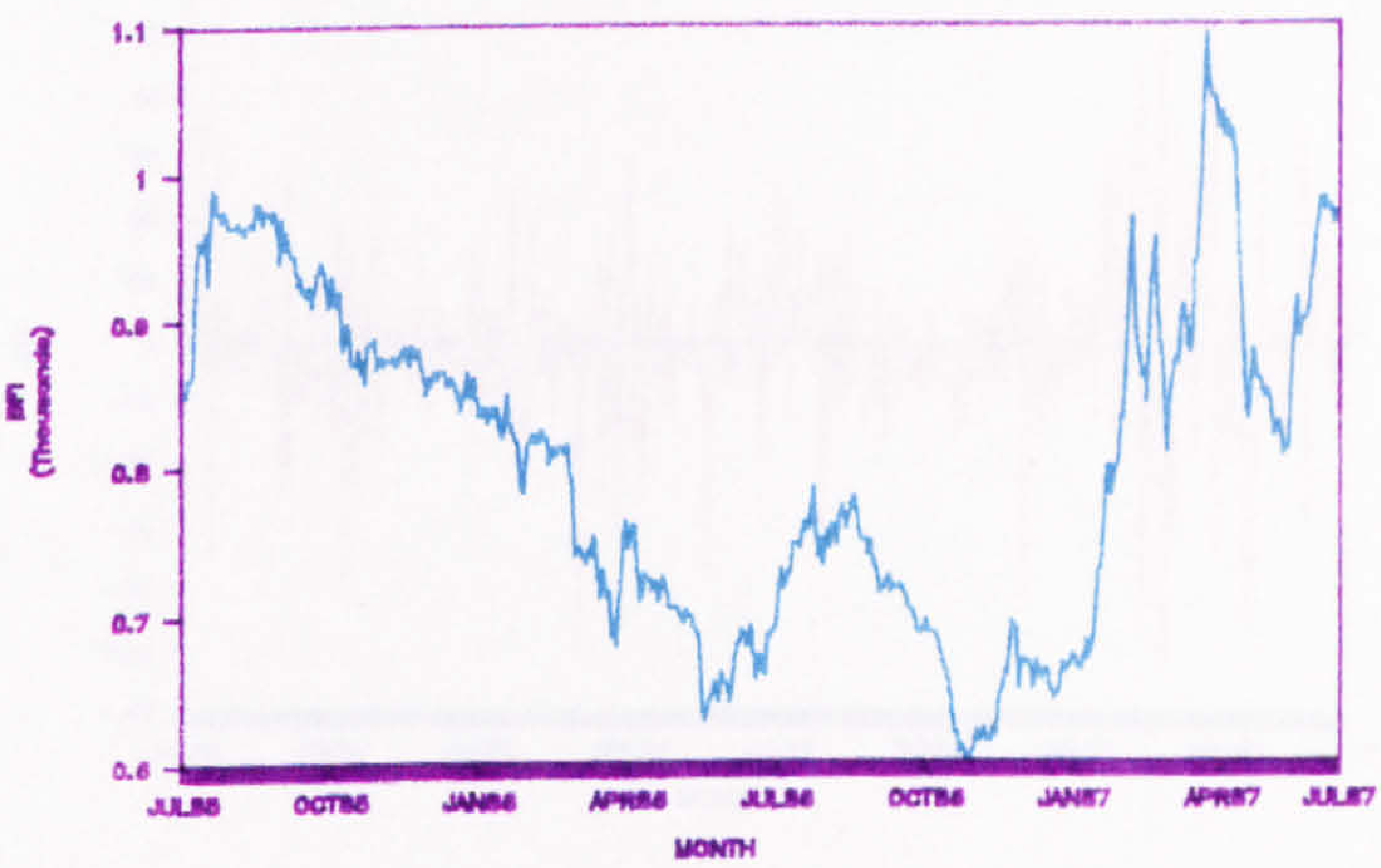
7.2.1 Random Walk tests

Table 1 contains the results of the random walk test. The next period's future price has been regressed on the current price and a constant as in (2). The hypothesis that $a=0$ and $b=1$ is tested by calculating the Dickey-Fuller (1981) Φ_1 statistic. This is a maximum likelihood ratio test and is calculated as a standard F-statistic. However, it is not distributed as an F-variable under the null. The approximate distribution for our sample size which consists of around 500

APRIL 1987 FUTURES



JULY 1987 FUTURES



OCTOBER 87 FUTURES

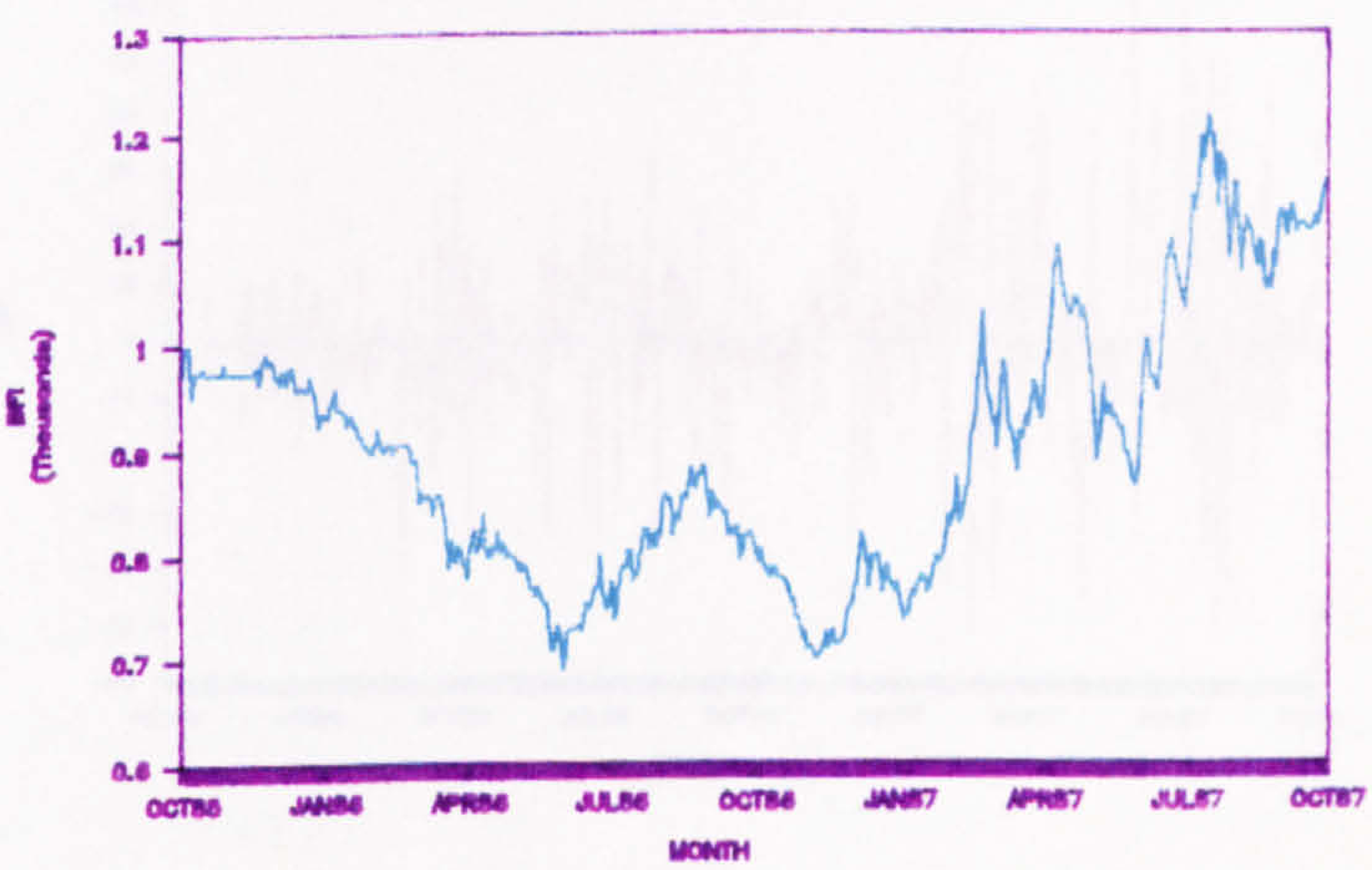


FIG. 7.1

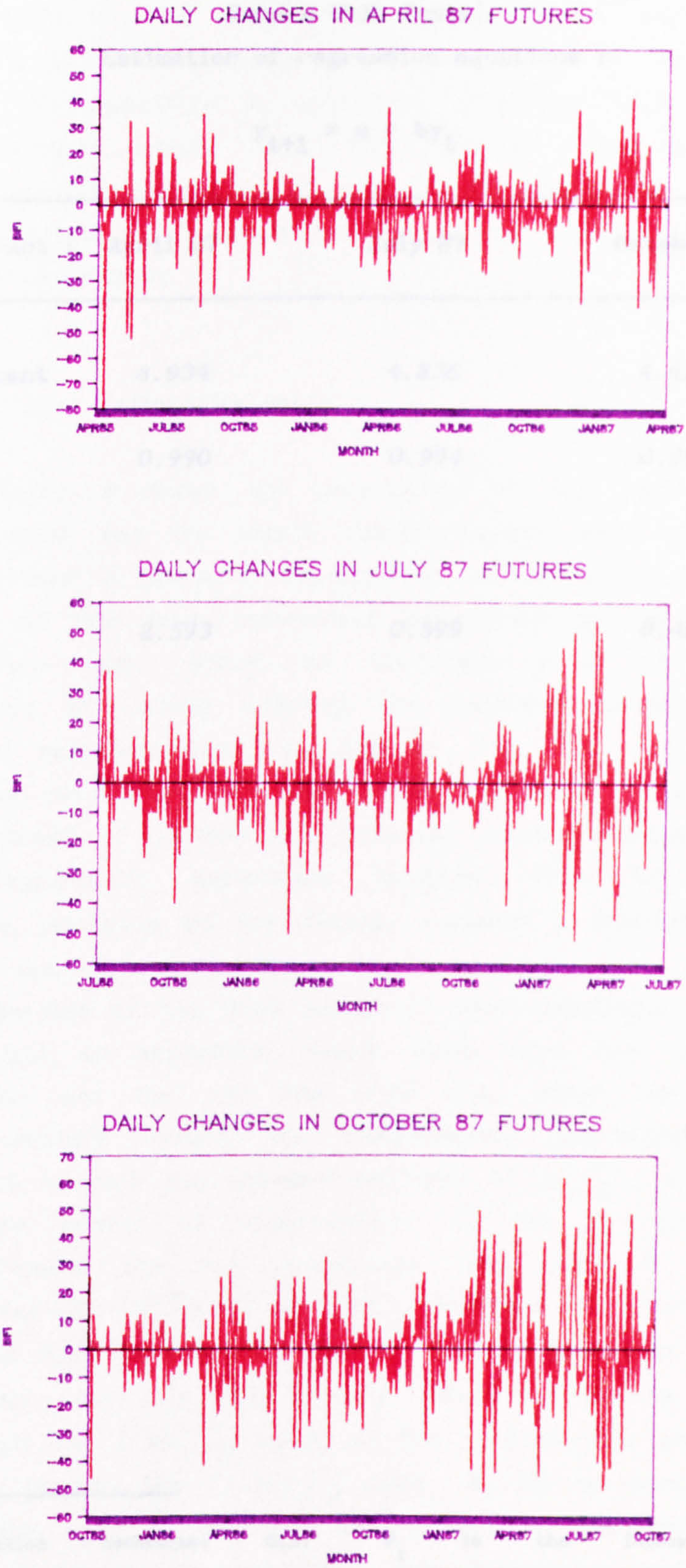

DAILY CHANGES IN APRIL 87 FUTURES
APR85 JUL85 OCT85 JAN86 APR86 JUL86 OCT86 JAN87 APR87
MONTH
DAILY CHANGES IN JULY 87 FUTURES
JUL85 OCT85 JAN86 APR86 JUL86 OCT86 JAN87 APR87 JUL87
MONTH
DAILY CHANGES IN OCTOBER 87 FUTURES
OCT85 JAN86 APR86 JUL86 OCT86 JAN87 APR87 JUL87 OCT87
MONTH

FIG. 7.2

Table 7.1

Random Walk Tests[1]

Estimation of regression equations :

$$y_{t+1} = a + by_t$$

Contract :	April 87	July 87	October 87
Constant	*8.934*	*4.836*	*4.423*
y_t	*0.990*	*0.994*	*0.995*
Φ_1	*2.593*	*0.599*	*0.420*

[1] Estimation technique: OLS. Φ_1 is the Dickey-Fuller statistic estimated as a standard F-statistic but distributed as in Table IV of Dickey-Fuller (1981).

observations is given in Dickey-Fuller (1981) Table IV. According to this table, the Φ_1 statistic is significant at the 10% level if it is larger that 3.79. On the other hand the calculated Φ_1 statistics shown on Table 1 are considerably smaller that this critical value so the random walk implication of the EMH/RE hypothesis cannot be rejected on the basis of these tests even at the 10% significance level.

7.2.2 *Weak Rationality tests*

Figure 3 shows the corellogram of the series Δf_t calculated from the sample autocorrelations $r(\tau)$. If Δf_t is indeed a serially uncorrelated white noise process then all the true theoretical autocorrelations $\rho(\tau)$, at non-zero lags, should be identically equal to zero. Because of random sampling the empirical estimates of these autocorrelations plotted on fig. 7.3 will show random deviations from the actual theoretical values. An assessment of whether the estimated autocorrelations show a statistically significant deviation from the zero values predicted by the theory, requires a knowledge of their sampling distribution.

Because of the large number of observations (500), we can use an asymptotic result which says that in big samples and for $\tau \neq 0$ the $r(\tau)$ are, under the null, approximately normally and independently distributed with a mean of zero and standard deviation of $1/\sqrt{N}$, where N is the number of observations. At the 5% level of significance the null hypothesis that $\rho(\tau) = 0$ is rejected if $|N^{1/2}r(\tau)| > 1.96$. Therefore two horizontal dotted lines have been drawn on the corellogram in order to carry out this test visually. The first line is drawn through the $1.96/\sqrt{N}$ point on the vertical axis and the other through the $-1.96/\sqrt{N}$ point. It can be seen that for the April 87 contract all but one of the estimated autocorrelations lie well within the acceptance region as the EMH/RE hypothesis would suggest. However for the July

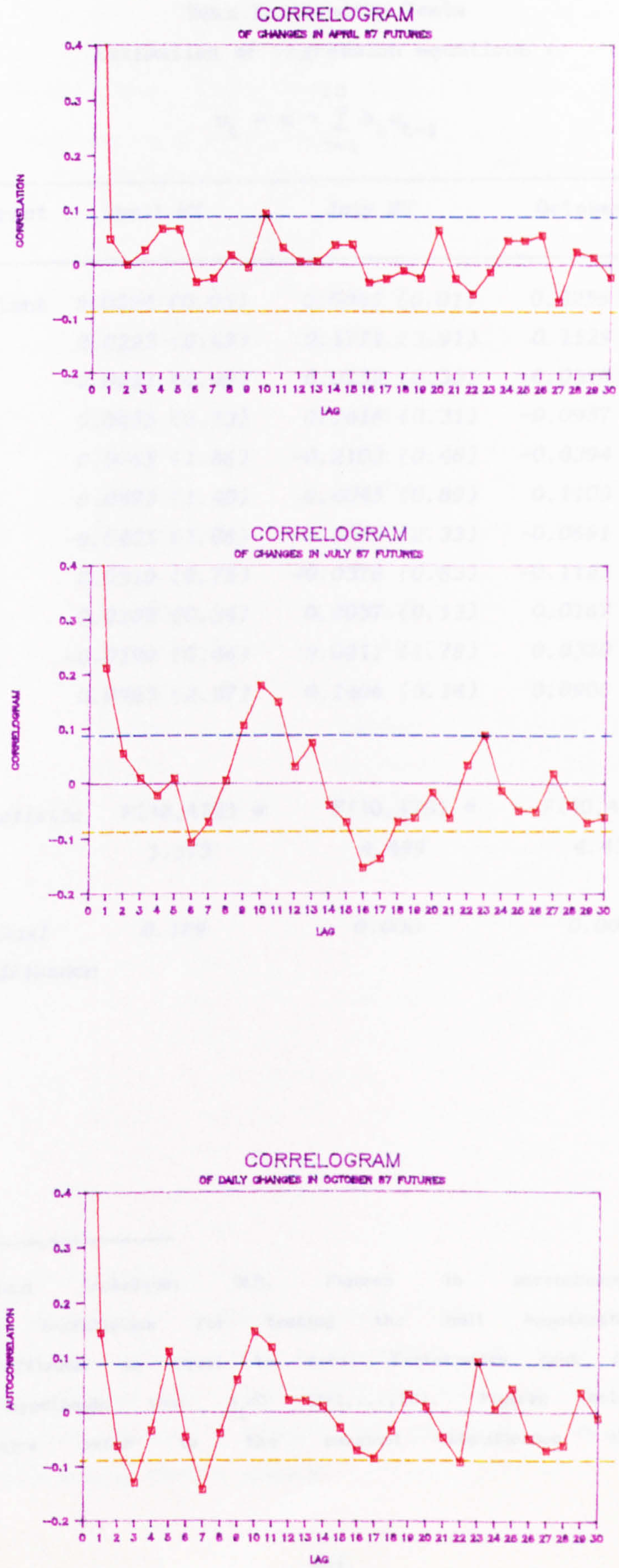

CORRELOGRAM
OF CHANGES IN APRIL 87 FUTURES
CORRELATION
LAG
CORRELOGRAM
OF CHANGES IN JULY 87 FUTURES
CORRELOGRAM
LAG
CORRELOGRAM
OF DAILY CHANGES IN OCTOBER 87 FUTURES
AUTOCORRELATION
LAG

FIG. 7.3

Table 7.2a[2]

Weak Rationality Tests

Estimation of regression equations :

$$u_t = a + \sum_{i=1}^{10} b_i u_{t-i}$$

Contract :	April 87	July 87	October 87
Constant	*0.0294 (0.05)*	*0.0045 (0.01)*	*0.3256 (0.46)*
u_{t-1}	*0.0223 (0.49)*	*0.1771 (3.91)*	*0.1529 (3.34)*
u_{t-2}	*-0.0221 (0.49)*	*0.0152 (0.33)*	*-0.0386 (0.83)*
u_{t-3}	*0.0055 (0.13)*	*0.1416 (0.31)*	*-0.0957 (2.06)*
u_{t-4}	*0.0765 (1.86)*	*-0.2103 (0.46)*	*-0.0394 (0.85)*
u_{t-5}	*0.0593 (1.43)*	*0.4045 (0.89)*	*0.1103 (2.39)*
u_{t-6}	*-0.0435 (1.06)*	*-0.1055 (2.33)*	*-0.0691 (1.51)*
u_{t-7}	*0.0310 (0.75)*	*-0.0376 (0.83)*	*-0.1125 (2.45)*
u_{t-8}	*0.0139 (0.34)*	*0.0057 (0.13)*	*0.0167 (0.37)*
u_{t-9}	*-0.0190 (0.46)*	*0.0811 (1.78)*	*0.0320 (0.70)*
u_{t-1}	*0.0963 (2.37)*	*0.1406 (3.14)*	*0.0900 (1.98)*
F-statistic	F(10,479) = *1.375*	F(10,478) = *4.499*	F(10,472) = *4.433*
Marginal Significance	*0.189*	*0.000*	*0.000*

[2] Estimation technique: OLS. Figures in parentheses are absolute t-statistics for testing the null hypothesis that the coefficient is equal to zero. F-statistics test for the joint hypothesis that $b_i=0$ (i=1,...,10). Figures below the F-statistics refer to the marginal significance of the test.

Table 7.2b[3]

Weak Rationality Tests

Portmanteau Test Statistics based on the estimated autocorrelations r(j) of the u's : $Q(p) = N \sum_{j=1}^{p} r^2(j)$

Contract :	April 87	July 87	October 87
p	Q(p)	Q(p)	Q(p)
2	*1.066*	*23.916*	*12.344*
	(0.587)	*(0.000)*	*(0.002)*
5	*5.585*	*24.256*	*27.178*
	(0.349)	*(0.000)*	*(0.000)*
10	*11.004*	*54.066*	*51.352*
	(0.357)	*(0.000)*	*(0.000)*

[3] The portmanteau statistic based on the first p autocorrelations Q(p), is asymptotically distributed as a χ^2_p variable under the null hypothesis that the u's are a white noise process. Figures in parentheses denote the significance level of the Q - statistic.

87 and October 87 contracts a significant number of autocorrelations lie well outside the acceptance region and this evidence is not favourable to the EMH/RE.

These results are also mirrored in Tables 2a, 2b. The hypothesis that u_t follows a white noise process is tested by estimating the regression equations (4) and calculating the F-statistic for the exclusion of lagged $u's$. These calculations are reported in Table 2a where it can be seen that for the April contract the hypothesis that u is a white noise process cannot be rejected while for the other contracts the evidence is unfavourable to the white noise hypothesis.

Table 2b shows the calculated portmanteau statistics. These are based on the correlogram and have been calculated for various lags. Again the evidence from the April contract is consistent with EMH/RE while the evidence from the other contracts rejects the null hypothesis of zero autocorrelation.

We have also carried out another non parametric procedure in order to test whether the differenced price series follows a white noise process. This procedure is based on Durbins' (1969) cumulative periodogram test. It is a frequency domain alternative to the tests carried out above. The test relies on the idea that the theoretical spectrum of a white noise process is flat. Since the periodogram is an unbiased estimate of the spectrum, the cumulative periodogram should therefore tend to be a straight line but again we expect some deviations due to random sampling.

The estimated spectra of the series are plotted on fig. 4. The estimated spectrum does not seem to be flat as the theory would suggest. It also shows a peak at the trading week periodicity of 5 days which suggests that there might be a 'seasonal' day of the week effect in the data. The fluctuations in the estimated spectrum however could reflect the effects of random sampling. To carry out a rigorous test we use fig. 5. Each diagram shows 3 lines. The line that passes through the origin is the cumulative periodogram of the differenced price series

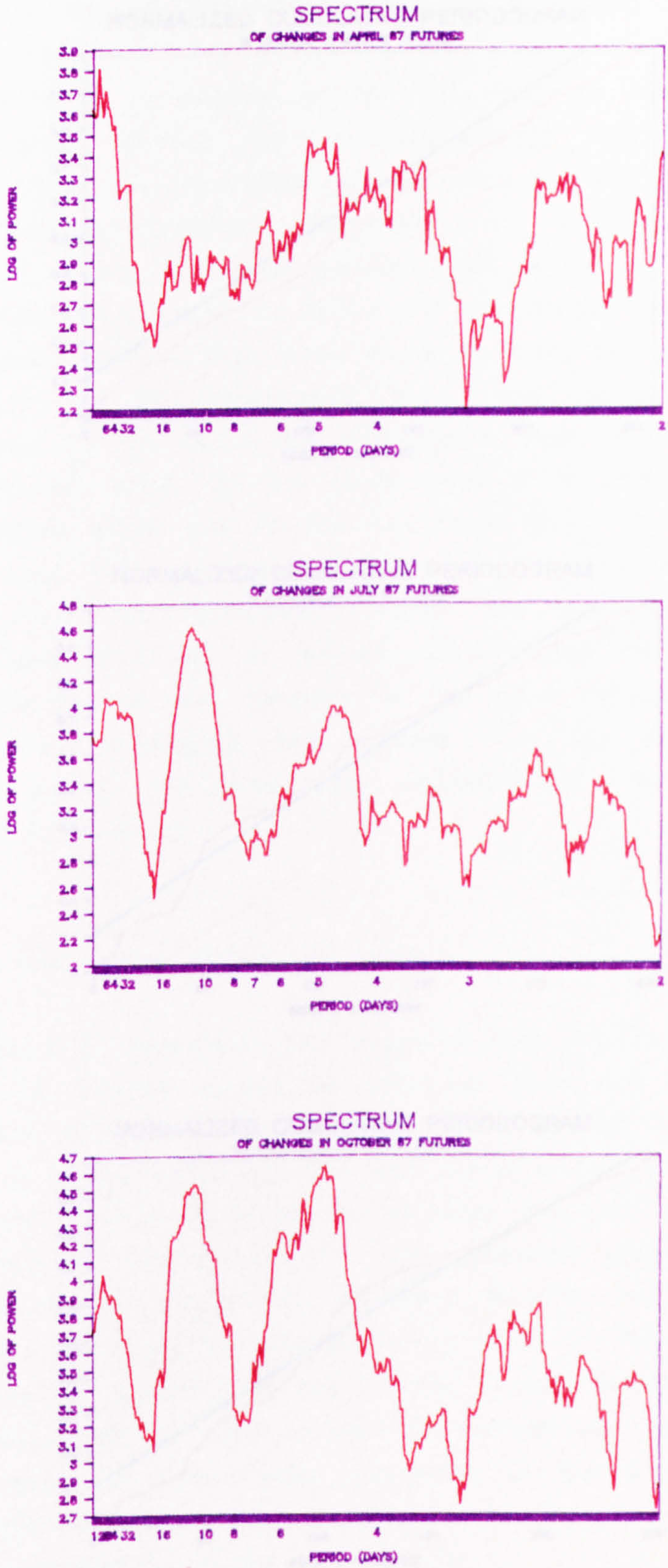

SPECTRUM
OF CHANGES IN APRIL 87 FUTURES
LOG OF POWER
PERIOD (DAYS)
SPECTRUM
OF CHANGES IN JULY 87 FUTURES
LOG OF POWER
PERIOD (DAYS)
SPECTRUM
OF CHANGES IN OCTOBER 87 FUTURES
LOG OF POWER
PERIOD (DAYS)

FIG. 7.4

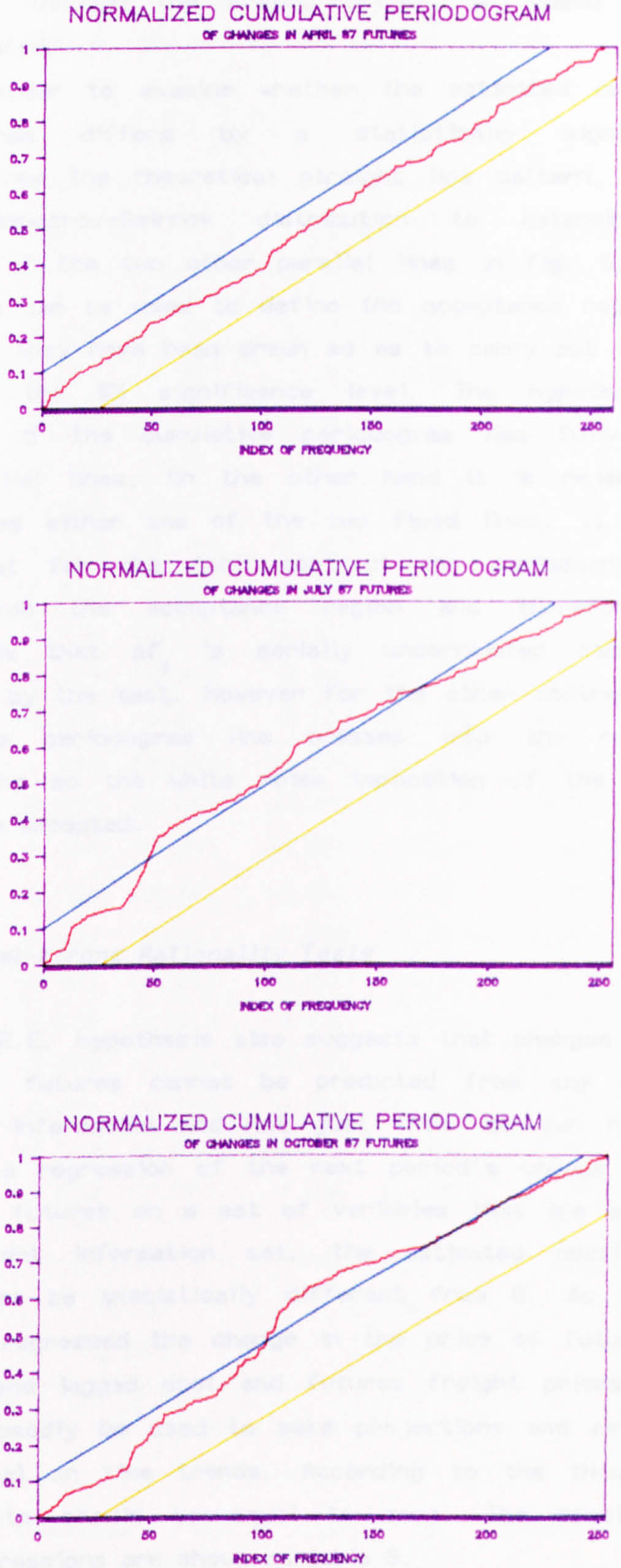

NORMALIZED CUMULATIVE PERIODOGRAM
OF CHANGES IN APRIL 87 FUTURES
INDEX OF FREQUENCY
NORMALIZED CUMULATIVE PERIODOGRAM
OF CHANGES IN JULY 87 FUTURES
INDEX OF FREQUENCY
NORMALIZED CUMULATIVE PERIODOGRAM
OF CHANGES IN OCTOBER 87 FUTURES
INDEX OF FREQUENCY

FIG. 7.5

and the theoretical value of this should be a straight 45^0 line through the origin, if Δf_t is indeed serially uncorrelated.

In order to examine whether the estimated cumulative periodogram differs by a statistically significantly amount from the theoretical straight line pattern, we use the Kolmogorov-Smirnov distribution to determine the position of the two other parallel lines in fig. 5. These two lines can be used to define the acceptance region. In our case they have been drawn so as to carry out a visual test at the 5% significance level. The hypothesis is accepted if the cumulative periodogram lies fully within the parallel lines. On the other hand it is rejected if it crosses either one of the two fixed lines. It can be seen that for the April contract the periodogram lies well within the acceptance region and therefore our hypothesis that Δf_t is serially uncorrelated cannot be rejected by the test. However for the other contracts the cumulative periodogram line crosses into the rejection region and so the white noise implication of the EMH/RE cannot be accepted.

7.2.3 Semi-strong Rationality Tests

The R.E. hypothesis also suggests that changes in the price of futures cannot be predicted from *any* current available information and not just from its own history. Thus in a regression of the next period's change in the price of futures on a set of variables that are part of the current information set, the estimated coefficients should not be statistically different from 0. As in (5) we have regressed the change in the price of futures on current and lagged spot and futures freight prices which can supposedly be used to make projections and estimates of cyclical or time trends. According to the theory all coefficients should be equal to zero. The results of these regressions are shown on table 3.

The null hypothesis that the coefficients of all

Table 7.3[4]

Semi-Strong Rationality Tests

Estimation of regression equations :

$$u_t = a + \sum_{i=1}^{10} b_i f_{t-i} + \sum_{i=1}^{10} c_i n_{t-i}$$

Contract :	April 87		July 87		October 87	
constant	4.874	(1.13)	5.473	(1.17)	4.692	(0.85)
f_{t-1}	0.005	(0.09)	0.191	(4.20)	0.165	(3.56)
f_{t-2}	-0.021	(0.32)	-0.183	(2.57)	-0.206	(2.90)
f_{t-3}	0.032	(0.52)	0.001	(0.01)	-0.070	(0.99)
f_{t-4}	0.065	(1.04)	-0.049	(0.69)	0.067	(0.94)
f_{t-5}	0.005	(0.08)	0.082	(1.16)	0.160	(2.29)
f_{t-6}	-0.119	(1.89)	-0.159	(2.24)	-0.193	(2.78)
f_{t-7}	0.076	(1.20)	0.079	(1.12)	-0.050	(0.71)
f_{t-8}	-0.035	(0.56)	0.045	(0.64)	0.138	(1.97)
f_{t-9}	-0.031	(0.50)	0.110	(1.56)	0.030	(0.43)
f_{t-10}	0.140	(0.32)	-0.131	(2.83)	-0.052	(1.10)
n_{t-1}	0.055	(0.44)	-0.003	(0.19)	-0.003	(0.17)
n_{t-2}	-0.178	(0.80)	-0.008	(0.49)	0.001	(0.04)
n_{t-3}	0.066	(0.29)	-0.001	(0.05)	0.005	(0.25)
n_{t-4}	0.237	(0.10)	-0.007	(0.41)	0.004	(0.18)
n_{t-5}	-0.461	(0.21)	0.003	(0.15)	0.006	(0.28)
n_{t-6}	0.136	(0.61)	-0.010	(0.60)	-0.010	(0.51)
n_{t-7}	-0.092	(0.41)	-0.024	(1.38)	-0.124	(0.63)
n_{t-8}	0.170	(0.77)	0.009	(0.50)	0.049	(2.55)
n_{t-9}	-0.155	(0.73)	-0.014	(0.86)	-0.032	(1.72)
n_{t-10}	0.024	(0.20)	0.046	(2.87)	0.014	(0.08)
F-statistic	$F(20,470) = 0.703$		$F(21,469) = 2.306$		$F(20,463) = 2.487$	
Marginal significance	0.824		0.001		0.000	

[4] Estimation technique: OLS. Figures in parentheses are absolute t-statistics. The F-statistic tests for the joint hypothesis that $b_i = c_i = 0$, $i=1,\ldots,10$.

variables, except possibly the constant, are 0 was tested by calculating the F-statistics reported at the bottom of the table. The value of the statistic was found to be 0.703 for the April contract which is very insignificant. However for the July and October contract the value of F was very significant and thus the EMH/RE should be rejected at the standard significance levels. Similar regressions with shorter lags were carried out and similar results were derived.

These results are somewhat mixed. The evidence from the April contract is favourable to EMH/RE. However the evidence from the July and October contracts tends to reject the implications of EMH/RE. When evaluating the significance of this latter evidence we should bear in mind that the two samples are not independent. Data for the July and October contracts cover a period of 8 quarters, 6 of which are overlapping. This might explain why both generate similar results. Surprisingly the April and July contract also overlap over a period of 6 quarters out of 8 and yet the evidence from each sample is entirely different.

7.3 Term structure of time charter rates

In this section we test the efficient markets/ rational expectations hypothesis in the time charter markets. Shipowners, charterers and speculators can chose among time charter hire contracts of varying durations. The time charter is a rental contract which stipulates that over its duration control of the ship passes from the shipowner to the charterer. At the one extreme there are very short term time charters which cover one voyage only, while at the other end the ship might be chartered for a period which, especially in the case of tankers, might exceed 10 years and so cover most of its economic lifetime. The owner/charterer will often consider the profitability of selling/buying over a period of time on the spot market or under a series of short term time charters or under a single long term charter or possibly a combination of these strategies. In the zero uncertainty perfect foresight case any strategy would give the same return because it can be easily shown that if this equality does not hold all sellers will switch from a low profit charter market A to another more profitable charter market B while at the same time all buyers will leave B and switch to the cheaper market A. This condition allows us to derive the fundamental equation for the term structure of time charter rates in the zero uncertainty case.

Consider the following alternative strategies open to a shipowner/charterer over a period of time of length T. On the one hand the economic agent can operate by arranging a long term T period time charter or by arranging a series of T short term one period time charters. The profitability/cost of either of the two strategies should be the same at equilibrium. If H_t^T is the fixed prearranged time charter rate on a T period contract at time t while H_t^1 is the short term one period time charter then the present value of the stream of payments that the two strategies give should be equal. The present value of the long T period contract (V^L) is

$$V_t^L = H_t^T + \frac{H_t^T}{d_{t,1}} + \frac{H_t^T}{d_{t,2}} + \ldots + \frac{H_t^T}{d_{t,T-1}} \qquad (6)$$

while the present value (V^S) on the alternative strategy of sequential short term charters is

$$V_t^S = H_t^1 + \frac{H_{t+1}^1}{d_{t,1}} + \frac{H_{t+2}^1}{d_{t,2}} + \ldots + \frac{H_{t+T-1}^1}{d_{t,T-1}} \qquad (7)$$

where $d_{t,k}$ is a discounting factor defined as

$$d_{t,k} = \prod_{i=1}^{k} (1+r_{t+i})$$

where r is the return on capital. In the perfect foresight case, the present value of the two strategies should be equal, thus

$$V_t^S = V_t^L \tag{8}$$

In the realistic case where there is uncertainty and foresight cannot be perfect it shall be assumed that, after allowing for a risk premium, a similar relationship holds in terms of the expected values of the variables in the above equation, which would also be true under risk neutrality. Thus

$$E_t V_t^S = V_t^L \tag{9}$$

or using (6), (7)

$$H_t^1 + \frac{E_t H_{t+1}^1}{d_{t,1}} + \frac{E_t H_{t+2}^1}{d_{t,2}} + \ldots + \frac{E_t H_{t+T-1}^1}{d_{t,T-1}} = \tag{10}$$

$$H_t^T + \frac{H_t^T}{d_{t,1}} + \frac{H_t^T}{d_{t,2}} + \ldots + \frac{H_t^T}{d_{t,T-1}}$$

where E_t is the expectation operator conditional on information available at time t. On the RHS of (9) we have made use of the fact that at time t, V_t^L is non random both because long term time charter rates are fixed and also because the long term discount factor is observable from long term interest rates. This implies that $V_t^L = E_t V_t^S$.

Economic agents in the shipping markets are unlikely to be risk neutral so (9) and (10) should be interpreted as being approximately true possibly after allowing for a risk premium.

Up to here, no assumptions have been made about how expectations are formed. The term structure theory assumes that the above relationships are valid immaterially as to whether expectations are rational or not. If additionally it is assumed that expectations are rational then the joint hypothesis implies testable restrictions about the stochastic relationships in the data. Define the observable u_t as the excess profit on the long term contract which is given by

$$u_t = V_t^L - V_t^S \tag{11}$$

or using (6), (7) and (10)

$$u_t = \frac{H^1_{t+1} - E_t H^1_{t+1}}{d_{t,1}} + \frac{H^1_{t+2} - E_t H^1_{t+2}}{d_{t,2}} + \dots$$

$$\dots + \frac{H^1_{t+T-1} - E_t H^1_{t+T-1}}{d_{t,T-1}} \tag{12}$$

Thus u_t is a weighted average of forecast errors of future short term charter rates. Assuming rationality u_t should be uncorrelated with any part of the current information set. From (12) it can be seen that u_{t-j} belongs to the information set for $j \leq T-1$ but not necessarily for $j > T-1$. Thus u_t should be at most an MA(T-2) process. In addition if expectations are rational then u_t should be unpredictable on the basis of any subset of the information set.

The empirical investigation uses quarterly data on the short term (one period) time charter rate H_t^1 and also for the four quarter (12 months) time charter rate H_t^4. The figures are expressed in \$ per dwt per month. The above specified relationships between the theoretical concepts H_t^1 and H_t^T should also be true for their empirical counterparts after we set T=4 in the above equations. The same statistical analysis is performed on four independent sets of data. Each data set refers to a different size group of ships. The first set uses data on ships between 12000-20000 dwt, the second looks at the 20000-35000 dwt group, the third is the 35000-50000 dwt group while the fourth is the 50000-85000 dwt group.

The statistical analysis

The following section reports the results of unbiasedness, weak rationality and semi-strong rationality tests. Table 4 reports the results of unbiasedness tests. These are based on equation (11). This implies that in the regression equation (11')

$$V_t^S = a + bV_t^L + u_t \qquad (11')$$

the null hypothesis that $a=0$ and $b=1$ should not be rejected. The hypothesis is tested by calculating the regression and using a χ^2 test on the unrestricted coefficients.

Weak rationality tests are reported in table 5 which test the implication of the R.E hypothesis that the excess profit u_t between the two chartering policies should be at most an MA(2) process. These tests are based on the correlogram of the $u's$ as well as on estimated autoregressions of u on its own history.

Table 6 reports the results of semi-strong rationality tests. The R.E hypothesis suggests that u_t is not only unpredictable on the basis of past $u's$ but also on the basis of any variable which belongs to the information set. The test is performed by regressing u_t on a subset of the information set and testing for the significance of the coefficients. The chosen subset includes lagged freight rates (F), fuel prices (P_b) as well as lagged one year time charter rates (H^4).

The error term of the regression equations is autocorrelated. This is because the (forecast) error is a weighted average of future forecast errors of short term charter rates, as equation (12) shows. Thus the Hansen &

Hodrick procedure has been used in order to take account of this problem. This procedure is is not the most powerful but it is easy to implement and gives unbiased estimates. On the other hand a GLS procedure would give biased results. This is because GLS implicitly filters the data and the bias is due to the fact the condition of econometric exogeneity is not satisfied. The u_t is in general correlated with future values of the regressors. To carry out the procedure the variance covariance matrix of the error term in the regressions is calculated from the first 3 elements of the covariogram of u and has a Toeplitz matrix form. Thus all elements of the central diagonal are equal to the variance of u. Elements in the first diagonals of the main one are set equal to $r(1)$ and those of the second diagonals are set equal to $r(2)$. All other elements are set equal to zero which is true under the null.

7.3.1 Unbiasedness Tests

Table 4 shows the results of the unbiasedness tests. The actual profit on a sequence of short term charters V_t^S is regressed on the profit of the long term charter V_t^L as in the regression equation (11'). The regressions have been carried out on four independed sets of data corresponding to various size groups. According to the theory V_t^L should be an unbiased predictor of V_t^S since the expected profit on the two strategies should be equal.

Table 4 also reports a χ^2 test on the hypothesis that $a=0$ and $b=1$. For the size groups 20000-35000 and 35000-50000 this joint hypothesis is rejected by the data at the 5% significance level. For the first and fourth size groups the hypothesis cannot be rejected at the 5% significance level, but this result is very marginal. The rejection of the hypothesis might be due to the existence on a non-zero risk premium which would imply violation of the assumption $a=0$. A less stringent version of the term structure/rational expectations hypothesis is tested with

Table 7.4[5]

Unbiasedness Tests

Estimation of regression equations :

$$V_t^S = a + bV_t^L$$

Size Group :	10000-20000	20000-35000	35000-50000	50000-85000
a	*0.71 (0.45)*	*0.52 (0.29)*	*0.77 (0.25)*	*0.47 (0.24)*
b	*0.81 (0.13)*	*0.85 (0.10)*	*0.75 (0.09)*	*0.83 (0.10)*
χ^2	*5.891*	*7.465*	*16.383*	*5.592*
Marginal Significance	*0.053*	*0.024*	*0.000*	*0.061*
t-statistic	*1.446*	*1.558*	*2.705*	*1.628*
Marginal Significance	*0.155*	*0.126*	*0.009*	*0.110*

5Estimation technique: OLS. Standard errors and test statistics have been calculated using the Hansen & Hodrick (1980) procedure. Figures in parentheses are estimated standard errors. The χ^2 statistic tests for the joint hypothesis that a=0 and b=1. Under the null, this is asymptotically distributed as a χ^2_2 variable. The t-statistic tests for the hypothesis that b=1.

the t-statistics reported towards the bottom of the table. These test for the hypothesis that $b=1$ while the value for a is not constrained. For no size groups could this hypothesis be rejected at the 5% level.

Overall the results of the unbiasedness tests are favourable to the less stringent version of the EMH/RE although the acceptance of the hypothesis is somewhat marginal.

7.3.2 Weak Rationality Tests

Weak rationality tests have been calculated based on the correlogram of u_t. The results are shown on fig. 6. The theory predicts that u_t should follow at most an MA(2) process. Thus under the null the true autocorrelations of higher order than 2 are equal to zero ($\rho(j)=0,\ \ j\geq 3$). This restriction of the term structure/rational expectations hypothesis can be tested on the correlogram of u_t. The first two sample autocorrelations are indeed much higher than the remaining ones. In order to test whether the estimated autocorrelations differ significantly from their theoretical values, their sampling distribution under the null hypothesis must be known. The following result is used which says that for an MA(q) process all sample autocorrelations of higher order than q are asymptotically normally distributed with mean zero and variance given by the following expression

$$Var(r(j)) \cong [\ 1 + 2 \sum_{j=1}^{q} \rho(j)\ ]/\ N \qquad j>q \qquad (15)$$

where N is the number of observations. Expression (15) involves the unknown theoretical autocorrelations $\rho(j)$ but can be estimated consistently by using the first q order sample autocorrelations $r(j)$ in the above expression. This method has been used in order to calculate this quantity and two dotted parallel lines

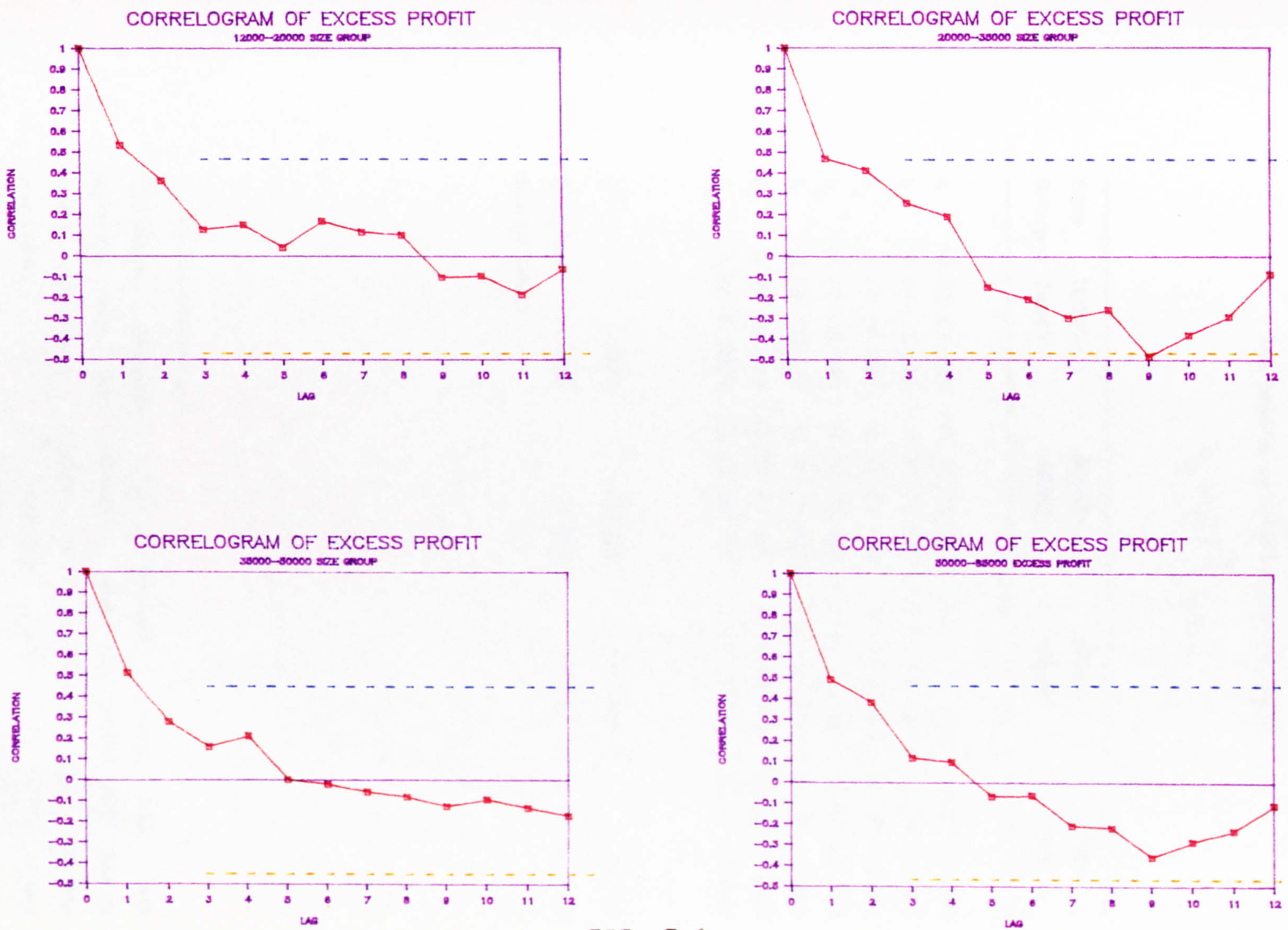

CORRELOGRAM OF EXCESS PROFIT
12000–20000 SIZE GROUP
CORRELOGRAM OF EXCESS PROFIT
20000–35000 SIZE GROUP
CORRELOGRAM OF EXCESS PROFIT
35000–50000 SIZE GROUP
CORRELOGRAM OF EXCESS PROFIT
50000–85000 EXCESS PROFIT
CORRELATION
LAG

FIG. 7.6

Table 7.5[6]

Weak Rationality Tests

Estimation of regression equations :

$$u_t = a + \sum_{i=3}^{8} b_i u_{t-i}$$

Size Group :	10000-20000	20000-35000	35000-50000	50000-85000
a	-0.05 (1.05)	-0.10 (2.10)	-0.10 (1.70)	-0.11 (1.82)
b_3	0.06 (0.30)	0.35 (1.73)	0.04 (0.16)	0.23 (1.02)
b_4	0.13 (0.73)	0.35 (2.03)	0.45 (2.40)	0.23 (1.29)
b_5	-0.17 (0.94)	-0.24 (1.56)	-0.21 (1.20)	-0.20 (1.16)
b_6	0.18 (1.07)	-0.16 (1.08)	0.11 (0.59)	0.07 (0.41)
b_7	0.08 (0.47)	-0.38 (2.19)	-0.12 (0.64)	-0.32 (1.61)
b_8	0.00 (0.00)	-0.03 (0.14)	-0.12 (0.66)	-0.11 (0.64)
χ^2	3.021	12.359	7.045	6.582
Marginal Significance	0.806	0.054	0.317	0.361

[6] Estimation technique: OLS. Standard errors and test statistics have been calculated using the Hansen & Hodrick (1980) procedure. Figures in parentheses are absolute t-statistics. The χ^2 statistic tests for the null hypothesis that all coefficients on the lagged u's are equal to zero. Under the null it is asymptotically distributed as a χ^2_6 variable.

have been drawn on fig. 6 at a height given by the estimated value of (15) multiplied by 1.96. These lines can be used in order to test at the 5% significance level the hypothesis that autocorrelations of higher order than 2 are equal to 0. It can be seen that all the empirical autocorrelations lie well within the acceptance region which is bounded by the two dotted lines and therefore the hypothesis that u_t follows an MA(2) process cannot be rejected. No doubts about the hypothesis should be cast by the fact that the correlogram might exhibit slowly moving patterns at higher lags. This is because the sampling errors of the $r(j)$'s are closely correlated when the process is not white noise and this can produce some random artificial cyclical movements in the correlogram which should not be interpreted as true.

Weak rationality tests have also been performed based on the regression equation (13).

$$u_t = a + \sum_{j=3}^{m} b_j u_{t-j} + e_t \tag{13}$$

The theory predicts that $b_i = 0$, $i=3,\dots,m$. This implication is tested with a χ^2 test on the coefficients of the regression equation (13). The results are shown on Table 5. Under the null the test statistic is distributed as a χ^2_8 variable. The last line of the table shows the marginal significance of the test. It can be seen that for all size groups the test is not significant at the 5% level. The hypothesis comfortably passes the test except for the 20000-35000 group were the result is marginal.

7.3.3 Semi-strong Rationality Tests

Table 6 shows the results of semi-strong rationality tests. The R.E hypothesis suggests that the excess profit u_t should be unpredictable on the basis of any variables which belong to the information set. The test is performed by regressing u_t on a subset of the information

Table 7.6[7]

Semi-Strong Rationality Tests

Estimation of regression equations :

$$u_t = a + \sum_{i=1}^{6} b_i F_{t-i} + \sum_{i=1}^{6} c_i Pb_{t-i} + \sum_{i=1}^{6} d_i H^4_{t-i}$$

Size Group :	10000-20000	20000-35000	35000-50000	50000-85000
a	-2.08 (0.89)	-0.11 (0.03)	-7.95 (1.16)	5.61 (1.08)
b_1	0.37 (1.53)	0.39 (1.06)	0.17 (0.50)	0.63 (1.65)
b_2	0.05 (0.19)	0.38 (1.03)	-0.35 (1.27)	0.32 (0.90)
b_3	-0.58 (2.64)	-0.07 (0.20)	-0.23 (0.75)	-0.30 (0.85)
b_4	0.07 (0.29)	0.11 (0.30)	0.16 (0.54)	0.69 (2.00)
b_5	-0.22 (1.01)	-0.04 (0.04)	-0.29 (1.42)	-0.26 (0.82)
b_6	-0.11 (0.42)	-0.56 (1.98)	-0.29 (1.10)	-0.17 (0.61)
c_1	-0.48 (1.18)	-1.05 (1.40)	-0.53 (0.89)	-1.48 (1.47)
c_2	-0.27 (0.77)	-0.49 (0.67)	0.80 (1.35)	-0.54 (0.59)
c_3	0.60 (1.79)	0.37 (0.53)	0.26 (0.35)	0.32 (0.36)
c_4	0.01 (0.01)	0.35 (0.54)	0.34 (0.53)	-1.18 (1.36)
c_5	-0.17 (0.45)	-0.34 (0.52)	0.15 (0.30)	0.69 (0.67)
c_6	0.70 (1.82)	0.97 (1.74)	0.82 (1.68)	0.54 (0.71)
d_1	0.14 (0.36)	0.39 (1.04)	0.29 (0.61)	0.76 (1.50)
d_2	0.38 (0.75)	0.28 (0.57)	-0.14 (0.22)	-0.27 (0.38)
d_3	-0.15 (0.26)	-0.57 (0.89)	-0.63 (0.87)	0.64 (0.75)
d_4	-0.35 (0.64)	0.07 (0.11)	0.12 (0.15)	-0.20 (0.23)
d_5	0.58 (0.98)	0.26 (0.39)	1.04 (1.25)	0.44 (0.49)
d_5	-0.44 (0.89)	-0.30 (0.57)	-0.90 (1.39)	-0.83 (1.24)
χ^2	22.596	26.053	27.672	20.127
Marginal Significance	0.207	0.099	0.067	0.326

[7] Estimation technique: OLS. Standard errors and test statistics have been calculated using the Hansen & Hodrick (1980) procedure. Figures in parentheses are absolute t-statistics. The χ^2 statistic tests for the joint hypothesis that $b_i = c_i = d_i = 0$, $i=1,\dots,6$. Undert the null, it is asymptotically distributed as a χ^2_{18} variable.

set and testing for the significance of the coefficients. This subset includes lagged freight rates (F), fuel prices (Pb) as well as lagged one year time charter rates (H^4)[8]. Accordingly, regression equation (14) is specified as follows

$$u_t = a + \sum_{i=1}^{m} b_i F_{t-i} + \sum_{i=1}^{m} c_i Pb_{t-i} + \sum_{i=1}^{m} d_i H^4_{t-i} \qquad (14)$$

This equation is estimated and the implication of the EMH/RE hypothesis that $b_i = c_i = d_i = 0,\ i=1,\dots m$ is tested. The test statistic is based on the deviations of the estimated coefficients from their theoretical value of zero. This statistic is reported towards the bottom of the table 6. Under the null, it is distributed as a χ^2_{18} variable. The last row of the table reports the marginal significance level of the test. It can be seen that the hypothesis is acceptable for all size groups at the 5% significance level. The result is marginal only for the third size group.

Overall it can be said that the results of the unbiasedness, weak and semi-strong rationality tests are favourable to the term structure/rational expectations hypothesis in the time charter markets.

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[8] Lagged short term charter rates have not been included in the set of regressors because of multicollinearity. This arises from the fact that there is a linear relationship between short term charter rates and the freight rate and bunker price regressors, as suggested by the theory of chapter 3. The exclusion of the redundant variable does not affect the test statistic results.

7.4 Newbuilding Futures

In this section data on newbuilding prices and second hand values is used in order to test a joint hypothesis of capital markets' efficiency and rational expectations. Newbuilding prices refer to ships which are for forward delivery since they can only be delivered after a considerable construction period has elapsed. On the other hand second hand values reported by various brokers refer to sales of ships which are for immediate delivery.

In addition to vintage considerations, differences between newbuilding and second hand values will also reflect the fact that the former are for future delivery where as the latter are for spot delivery. Abstracting for the moment from vintage and technological progress effects, let it be assumed that new and existing ships are identical in physical characteristics. In this hypothetical case any differences between newbuilding and spot prices will reflect the fact that the former are strictly for forward delivery. Assuming a one year lag between the time of ordering, when the newbuilding price is quoted, and the time of delivery when the price must be paid then the relationship between newbuilding values Pn_t and second hand spot prices P_t is the following

$$Pn_t = E_t P_{t+1} \tag{16}$$

that is, the newbuilding prices quoted by shipbuilders and accepted by investors today must equal the current expectation of spot prices at the time of delivery. Should the above equality not hold then there is the expectation of capital gains/losses for the investor which in the perfect foresight case would lead to massive capital inflows/outflows from the newbuilding market until the equality was restored. In the case where there is uncertainty but agents are risk neutral then (16) will again be true. If agents are risk averse then similar forces operate but to a smaller extent so (16) will now be true after allowing for a risk premium. Thus

$$Pn_t = k + E_t P_{t+1} \qquad (17)$$

where k is a constant reflecting the risk premium that investors need in order to accept newbuilding contracts. Allowing now for vintage effects and assuming that ships' depreciation and shipbuilding technological progress is constant over time, then (17) will also hold but now the constant k should be reinterpreted as representing risk premia, technological progress and depreciation effects. In theory, the risk premium might vary with market conditions but here its fluctuations will be considered to be sufficiently small so that it can be treated as a constant.

In our empirical investigation we assume that relationship (17) is true in terms of the logarithms of the variables. The data for Pn_t and P_t are independently based indices so k will now also reflect the arbitrary basing of the indices and no economic significance can be given to this term anymore.

Up to here, no assumptions have been made about how expectations are formed. The theory presented above might hold, immaterially as to whether expectations are rational or not. This theory however on its own cannot be tested since expectations are unobservable. If it is additionally assumed that expectations are rational then this implies testable restrictions about the stochastic structure of the observable time series on Pn_t, P_t and other variables. The actual future price P_{t+1} will deviate from its expectation by a random forecast error v_{t+1}

$$P_{t+1} - E_t P_{t+1} = v_{t+1} \qquad (18)$$

If expectations are rational then this should be uncorrelated with any current information and in particular with its own history. Substituting (18) into (17) gives

$$P_{t+1} = - k + Pn_t + \upsilon_{t+1} \tag{19}$$

and where υ_{t+1} is uncorrelated with any current information and in particular with its own history and also with Pn_t. Thus our joint hypothesis regarding investors' behaviour and the formation of expectations implies that in a regression of P_{t+1} on Pn_t and other variables belonging to the current information set, the coefficient on Pn_t should be equal to 1 while all other coefficients should be equal to zero.

In this section we perform unbiasedness, weak and semi-strong rationality tests which test the various implications of the efficient markets/rational expectations hypothesis. Unbiasedness tests are based on equation (19). The future spot (second hand) price is regressed on the predictor which is the newbuilding price. The coefficient on the newbuilding price should be equal to one and this is tested with a standard F-statistic. Weak rationality tests are based on the idea that the difference between the newbuilding price (the predictor) and the future spot price, should reflect genuine new information and thus is uncorrelated with past forecast errors υ_{t-1} since these also belong to the current information set. The forecast errors υ_t are calculated (up to a constant) by simply taking the difference $P_{t+1} - Pn_t$. The weak rationality tests investigate whether this series obeys the laws of a white noise process as the theory would predict. Tests are performed based on the correlogram of the series. In addition the following regression is considered

$$\upsilon_t = a + \sum_{j=1}^{m} b_j \upsilon_{t-j} + e_t \tag{21}$$

and the hypothesis that $b_j=0$, $j=1,\ldots,m$ is tested using a standard F-test.

Semi-strong rationality tests are performed by regressing the forecast error υ_t on an extended set of variables which are part of the information set. The information subset chosen, consists of data on lagged forecast errors, world economic activity (Y), the size of the fleet (K) and time charter rates (H^4) which could supposedly be used in order to make predictions of future υ's. This leads to the following regression equation being considered

$$\upsilon_t = a + \sum_{i=1}^{m} b_i \upsilon_{t-i} + \sum_{i=1}^{m} c_i Y_{t-i} + \sum_{i=1}^{m} d_i K_{t-i} + \sum_{i=1}^{m} e_i H^4_{t-i} \qquad (22)$$

In theory the coefficients of the regression should be equal to zero and this is also tested with a standard F-test.

7.4.1 *Unbiasedness Tests*

Table 7 reports the results of the unbiasedness tests. The estimated coefficient $\hat{b}$ on the newbuilding (futures) price is equal to 0.737. The F-statistic shows that the deviation from the theoretical value of 1 is statistically significant at the 0.05 level.

7.4.2 *Weak Rationality Tests*

Table 8 shows some of the results of weak rationality tests that have been performed. The regression equation (21) has been estimated. The t-statistics indicate that the coefficients on the first two lags are statistically significant at the 0.05 level. However the F-statistic which tests the joint hypothesis that the coefficients on all lags are equal to zero cannot be rejected at the 0.10 significance level.

Weak rationality tests have also been performed on the correlogram of the series υ_t. This is shown on fig. 7.7. According to the theory, υ_t should be white noise and sample correlations should not be statistically

Table 7.7[9]

Unbiasedness Tests

Estimation of regression equation:

$$P_{t+1} = a + bPn_t + u_t$$

a	b	S.E	D.W	F	M.S
0.811	0.737	0.329	1.332	4.971	0.035
(0.444)	(0.118)				

Table 7.8[10]

Weak Rationality Tests

Estimation of regression equation:

$$u_t = a + \sum_{i=1}^{4} b_i u_{t-i}$$

a	b_1	b_2	b_3	b_4	F	M.S
-0.144	0.605	-0.561	0.247	-0.162	2.223	0.103
(1.642)	(2.723)	(2.211)	(0.964)	(0.723)		

[9] Estimation technique: OLS. Figures in parenthese are estimated standard errors. The F-statistic tests for the hypothesis that b=1 while M.S is the marginal significance of this statistic calculated from the F(1,25) distribution.

[10] Estimation technique: OLS. Figures in parentheses are absolute t-statistics. F, tests for the hypothesis that b_i= 0, i=1,...,4. Under the null, it is distributed as an F(4,20) variable. M.S is the marginal significance level of the test.

FIG. 7.7

CORRELOGRAM

OF FORECAST ERROR

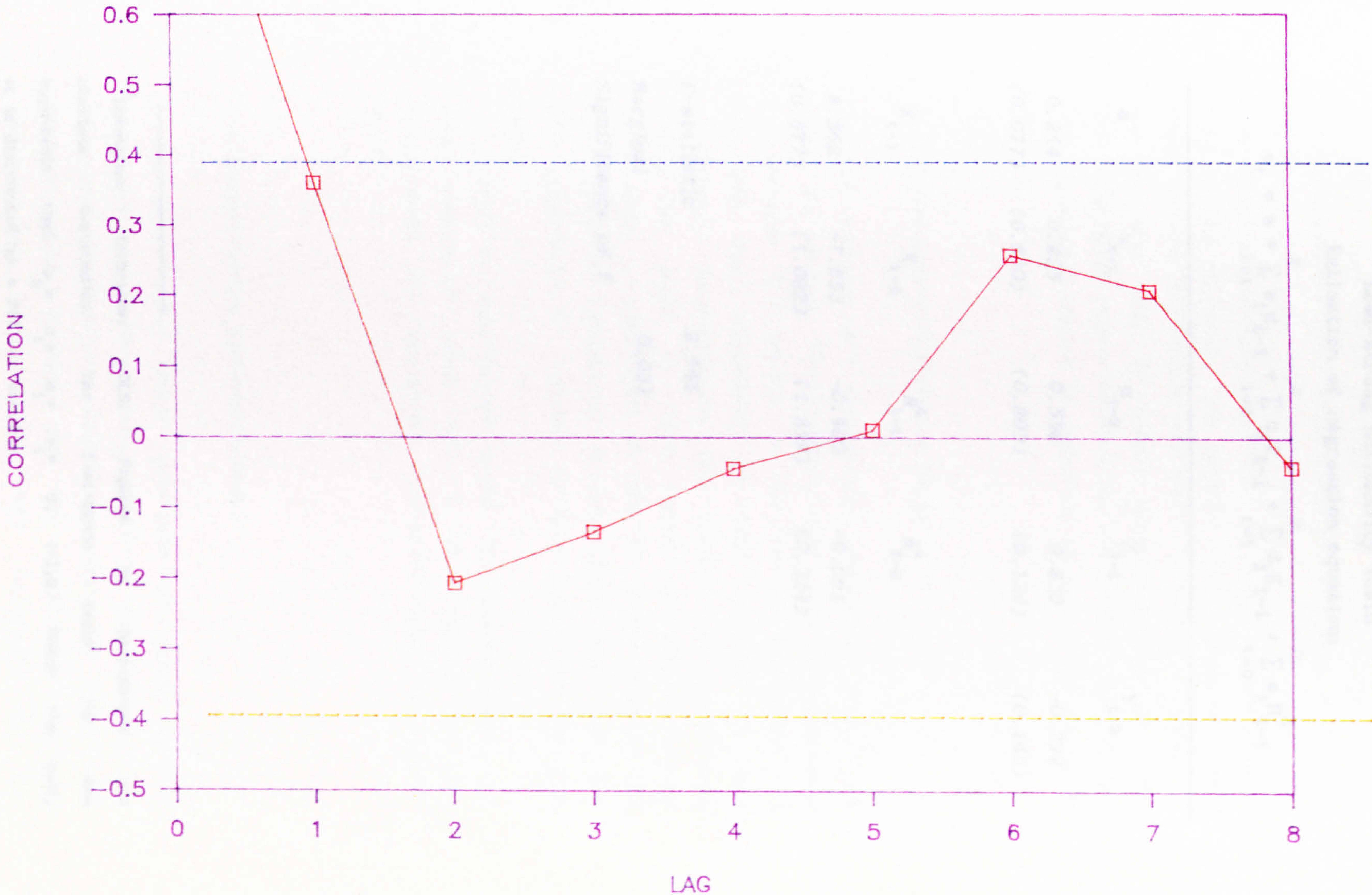

Table 7.9[11]

Semi-strong Rationality Tests

Estimation of regression equation:

$$u_t = a + \sum_{i=1}^{2} b_i u_{t-i} + \sum_{i=1}^{2} c_i Y_{t-i} + \sum_{i=1}^{2} d_i K_{t-i} + \sum_{i=0}^{2} e_i H^4_{t-i}$$

a	u_{t-1}	u_{t-2}	Y_{t-1}	Y_{t-2}
0.254	0.225	0.556	0.830	-0.792
(0.077)	(0.890)	(0.803)	(0.129)	(0.145)

K_{t-1}	K_{t-2}	H^4_{t-1}	H^4_{t-2}
8.562	-7.853	-0.900	-0.092
(0.877)	(1.082)	(1.859)	(0.324)

F-statistic	2.945
Marginal Significance of F	0.031

[11] Estimation technique: OLS. Figures in parentheses are absolute t-statistics. The F-statistic tests for the hypothesis that $b_i = c_i = d_i = e_i = 0$, $i=1,2$. Under the null, it is distributed as a $F(8,18)$ variable.

different from zero. In order to test this, we make use of the fact that, under the null, the sample autocorrelations are asymptotically normally distributed with zero mean and variance equal to $1/\sqrt{N}$, where N is the number of observations. Thus in order to carry out a test at the 5% level two parallel dotted lines have been drawn on the correlogram at the $\mp 1.96/\sqrt{N}$ height. It can be seen that all sample autocorrelations lie within the acceptance region defined by the dotted lines so the null hypothesis cannot be rejected by this test at the 5% level.

7.4.3 Semi-strong Rationality Tests

The results of semi-strong rationality tests are shown on table 9. The forecast error has been regressed on variables that belong to the current information set and that could supposedly be used in order to make predictions. According to the theory, all coefficients should be equal to zero. None of the individual t-statistics is significant at the 5% level. However the more powerful F-statistic is significant and thus the null hypothesis is rejected at the 0.05 level by this test.

Overall the results are mixed. The theory passes the weak rationality tests but it is rejected by the unbiasedness and semi-strong rationality tests at the 5% level.

7.5 Interpretation and conclusions

We have tested joint hypotheses of capital markets efficiency and rational expectations in shipping markets. The hypothesis has been tested separately for the freight futures, time charter and the newbuilding contract market. The evidence is quite favourable to the efficiency hypothesis in the time charter markets. However it is often rejected in the case of the freight futures and newbuilding contract markets at the 0.05 significance level. This does not necessarily imply rejection of the rationality of expectations hypothesis unless the capital markets model within which the R.E. hypothesis is embedded is maintained to be true.

The analysis has also implicitly assumed that the data corresponds to market clearing prices. This implicit assumption is somewhat suspect and might be the cause of the rejection of the hypothesis. Thus in the case of freight futures, the rejection might reflect the distorting influence of limit moves. In the case of the newbuilding market there is also evidence of a similar type of distortion. This might happen during periods of depression when second hand values fall to a level which is not sufficient to cover the cost of building ships even after allowing for subsidy. In such cases the newbuilding value will probably not move all the way down to the level that the theory predicts. The cost of construction seems to be a lower bound for newbuilding values. When current and expected second hand values fall below this level the newbuilding price will not follow since there will be little point in building ships at huge loss when there is also the less costly option of a temporary closure of the yard. During such periods quoted newbuilding prices reflect the cost of building ships rather that the market value of the vessel. Yards prefer to work on their existing order books and there is very little contracting at the inflated newbuilding price.

In the case of the time charter market there are no such constraints in the movements of rates and this might explain why the results of the tests are more favourable to the efficiency hypothesis tests in a market clearing environment. Thus it is not inconceivable that a modified version of the hypothesis which takes account of the distorting influences mentioned above, might be consistent with the empirical evidence.

CHAPTER 8

FORECASTING

This chapter illustrates how the model can be used for the purpose of forecasting and scenario planning. A base run forecast is presented and alternative scenarios involving unanticipated and anticipated oil shocks are also analysed.

8.1. Introduction

This chapter illustrates how the model developed in previous chapters can be used for forecasting purposes and scenario planning. The model has been routinely used in the past in order to generate forecasts about the future outlook of the shipping markets. These forecasts have been published regularly in the 'Economic Review' of the City University Business School. The forecast presented here is the one published in the Spring 1987 issue of the 'Economic Review'.

The model calculates equilibrium freight rates, ship prices, shipbuilding and scrapping among other things. One of the crucial assumptions of the model is that expectations in shipping markets are rational. This would be true in practise if speculation in real world markets made efficient use of available information. The rational expectations assumption might be somewhat extreme. According to some observers of the industry it is downright unrealistic. The evidence presented in the previous chapter is not conclusive on this matter. In the following paragraphs, it is argued that the rational expectations hypothesis can still be usefully adopted for the practical purpose of generating real world forecasts even though it might not be strictly true. Indeed, it might be the only reliable approach to modelling a possibly irrational real world.

Fundamentals and bubbles

The model, given the assumptions, purports to calculate the equilibrium price that will just allow an investor to earn a competitive return. We might call this price as the 'fundamental' or 'intrinsic' value of ships. At a given point in time the actual price might deviate from the 'fundamental' level by a smaller or larger irrational 'bubble' amount. Our rational expectations model assumes that investors always pay the 'fundamental' price i.e there are no speculative bubbles. This is a possibly unrealistic assumption. However, there is still a practical usefulnes in the predictions generated by rational expectations models. This arises from the fact that irrational pricing of assets cannot persist for long. Sooner or later values must move towards their 'intrinsic' level (which the model purports to calculate) as soon as the 'fundamentals reassert themselves'. The point in time when this happens cannot be easily foreseen even though it is bound to occur. These 'corrections' which set the price to its fundamental level imply loss of money for the investor. This creates real world forces that would tend to prevent the development of 'bubbles' and other irrationalities in the pricing of assets.

Even if such forces do not operate immediatelly, an analysis of the fundamentals, such as the one we carry out here, is useful for the practical purposes of forecasting. It can help to identify such irrationalities and to point out the direction of future corrections.

The Spring 1987 forecast

The following sections present the forecast published in the Spring 1987 issue of the "City University Business School, Economic Review". A base run set of assumptions regarding future growth in demand for freight, fuel prices, shipbuilding costs, interest rates and other external factors was used in order to generate a base run forecast. The main base run assumptions were that demand for dry cargo ton-miles grows by 3% p.a., tanker demand grows rapidly in the short run but settles at 2% in the long run while the oil price remains at about $18 per barrel. Section 8.2.3 considers the effects of an unanticipated oil shock while section 8.2.4 analyses the effects of an anticipated oil shock.

The Base Run analysis indicated that freight rates would soon increase by 50-90% and that ships were underpriced at the time by as much as 50-100%. Subsequent movements in prices and freight rates have vindicated these predictions. Dry cargo ship prices and time charter rates have doubled during the beginning of 1988.

8.2 Spring 1987 Forecast

THE OUTLOOK FOR THE WORLD SHIPPING MARKET 1987-2000

Major necessary adjustments in the stock of fleet, shipbuilding and scrapping capacity have taken place as the market has been gradually adjusting to the new post OPEC enviroment. These adjustments together with the likely higher growth rates in demand for freight that are associated with lower oil prices, are expected to provide a solid foundation for significant improvements in rates and values. We foresee significant increses in rates and values once the stock of fleet has completely adjusted to the lower levels of demand. The speed with which this undoubted long run recovery will take place will however be determined by the short term fluctuations in demand.

8.2.1 Recents Developments

The shipping industry has recently witnessed its worst depression in living memory. The severity of this depression was to a large extent due to the fact that it was completely unanticipated so that the growth rate of the fleet and of shipbuilding capacity was geared to the eventually unfulfilled expectations of high growth rates of demand. Now that the possibility of future oil shocks is recognised by investors, this will cause informed speculation and evasive action to take place that will cushion the effects of future oil shocks. The recent depression will probably go down in history as a unique episode not to be repeated again for a very long time.

The outstanding feature of 1986 has been the improvement in real tanker freight rates and in tanker values. These improvements have gone against recent trends. But the increase in profitability and the 50-80 per cent rise in tanker prices were largely anticipated by our forecast for the tanker market published last Spring.

The rise in freight rates has been caused by the increased demand for transportation generated by the temporary increase in long-haul Middle East exports. This increased demand was operating against an inelastic short term supply, (due to leads, lags and costs in breaking out of lay-up), leading to significant temporary increases in freight rates. The rise in tanker prices reflects the general optimism concerning the longer term future. Whether this is well founded or not is discussed in our forecast below.

Associated with the increase in OPEC supply has been the collapse in oil prices, and consequently bunker prices. Because demand for shipping transportation is very inelastic, a given percentage decrease in bunker prices will ceteris paribus lead to significant reductions in freight rates and consequently profit. In the case of tankers, the negative effect of lower bunker prices on profitability has been more than compensated by the effect of increased demand. This increase is estimated to have been in the region of 16%.

More recently, these trends have been reversing. Middle East production, and therefore demand for tankers, has fallen. The reactivated fleet has increased the available short term supply, generating further downward pressure on rates.

In the dry cargo market, the picture has been very different. The negative effects of the lower bunker prices, were reinforced by a drop in the general level of demand, of around 2%. This was mainly due to a reduction of around 13% in ton-miles generated by grain shipments.

The positive effects of the reduced supply of combined carriers in dry and the small reduction in the size of the fleet, have not been strong enough to cancel the negative factors.

In the last issue of the Review, we projeced strong time charter rate increases in the dry cargo market from 1987 onwards and consequently strong speculative increase in values within 1987 of a magnitude of around 90%. Rates have already increased significantly in the beginning of this year partly as a result of the recovery in oil and bunker prices restraining the supply. Prices have already increased by 50% since the end of last year as a result of improved longer term profit expectations.

The growth rate of the fleet, for a given level of shipbuilding costs, shipbuilding capacity and scrap prices is mainly determined by the level of ship prices, after we allow for lags and leads. Strong ship prices make shipbuilding a profitable proposition, and bring forward an increased supply of newbuildings. On the other hand during a period of depression shipyards are forced to close down, permanently or temporarily, in order to minimise losses. Existing ships are likely to be worth more dead rather than alive, leading to increased scrapping. This restrains the growth rate of the fleet both because shipbuilding contracts and because scrapping is stimulated.

Following the decrease in dry cargo prices, the planned future supply of dry cargo newbuildings (as measured by the order book) seems eventually to have fallen considerably. This was also reinforced by the icnrease in tanker values leading to substitution in shipbuilding of tankers for dry cargo newbuildings. Considerable permanent reductions in shipbuilding capacity and in government subsidies have taken place. These will have a restraining influence on the supply of new ships, as will the drop in the value of the dollar against the currencies of the major shipbuilding nations.

The dry cargo order book at the end of 1986 is 16.6

million dwt against 24.6 at the end of 1985. This is the lowest level since 1964. The corresponding figures for tankers are 15.2 million dwt in 1986 against 10.7 in 1985; that is, a 42% increase. Deliveries of dry cargo ships have also fallen to 16.0 million dwt, or around 5% of the fleet. Deliveries of tankers, however, have risen to 5.8 million dwt, which is 2.5% of the fleet.

The considerable investment in scrapping capacity that has taken place during the depression continued to generate a considerable demand for scrap during 1986, and is expected to do so in the future in spite of weak metal prices. The improvement of tanker values considerably reduced the supply of ships for scrap generated by the tanker fleet. This had a positive effect on scrap prices and consequently on the supply of dry cargo ships for scrap. This increased to 15.5 million dwt, or 4.7% of the fleet. This figure is also partly attributable to the very depressed dry cargo prices. Taking into account losses and conversions the dry cargo fleet showed a negative growth rate of -1% for the first time in its post war history. Because of the improvement in tanker values, tanker scrapping fell considerably, down to 15.0 million dwt against 31.0 in 1985. However, this was not sufficient to prevent a 3% reduction in the size of the fleet.

8.2.2. The Base Run Forecast

Behind the assumptions of the Base Run lies the assumption of permanently weak oil prices. Oil prices are assumed to remain at $18 in 1987 prices. Therefore demand in the dry cargo market is allowed to grow by 3% p.a., which is 1.5% higher than the average growth rate over the last seven years. This reflects our belief that recent growth rates have been abnormally low because of the negative effects of the oil shock of the seventies. Lower oil prices are likely to contribute to higher growth rates in world economic activity and therefore in the demand for dry cargo freight.

Lower oil prices are also likely to be associated with higher demand for long haul OPEC oil. This is assumed to grow gradually from next year onwards, once last year's accumulated stocks have been run down. Therefore demand in the tanker freight market, as measured in ton-miles, is assumed to grow rapidly from 1988 onwards, before it settles to a long run growth rate of 2% p.a. Shipbuilding capacity is assumed to be falling up to the end of the decade but from then on it is assumed to be rising in line with total demand in the freight markets. Our assumptions regarding operating costs, nominal interest rates and metal prices reflect our assumptions regarding inflation which is assumed to be 3% p.a.

The outlook

The implications of our Base Run assumptions are shown in Tables 1 and 2.

Because of the speculative behaviour in the second hand markets, short run developments in prices, and therefore in scrapping and shipbuilding and consequently in the freight market as well, are very much influenced by the longer term outlook. A possible interpretation of the way our projections are generated is the following. The model, given say an optimistic set of assumptions, will allow prices to jump immediately to reflect this optimism. However, the size of the jump is limited by the fact that the higher price will stimulate the growth rate of the fleet (by reductions in scrapping and increased supply of newbuildings) which has a negative effect on future freight rates. The equilibrium price jump must be just enough to guarantee that these future freight rates will produce a competitive return to be earned on the initial price. Higher prices than the equilibrium ones are rejected by the model and are assumed to be rejected by investors, because they imply higher growth rates for the fleet and therefore lower freight rates and thus an insufficient return on capital. Similarly lower prices than the equilibrium one are also rejected by the model since they are likely to lead to lower growth rates of the fleet and therefore higher profits and thus an excess return on capital. Investors are assumed to immediately bid up or down prices towards the equilibrium level in order to eliminate the expectation of an excessively high or low return.

Given our assumptions dry cargo prices are projected to increase by 55% within 1987 as compared with the prices observed towards the end of 1986. This will imply of course an immediate drop in scrapping, down to 12.0 million dwt. Prices are also expected to increase by another 15% in the next two years implying futher falls in scrapping in the future. Indeed the scrapping rate is expected to average out at about 2% of the fleet in the next 10 years. The level of prices is also associated with increased profitability in shipbuilding and therefore an increased supply of new dry cargo ships. In the short run, however, deliveries cannot respond to the unanticipated increase in prices since they are predetermined by past decisions, which were based on a more pessimistic outlook. Deliveries are projected to fall to 11.0 million dwt in 1987 in the light of recent levels in the order book and commencements.

The supply of new ships, as measured by the order book, is expected to increase following the increase in dry cargo prices. The order book is projected to increase to 28.7 million dwt by the end of 1987. This seems consistent with our assumptions of a doubling in the growth rate of demand from the recent average of 1.5% up to 3% p.a. This increase in the order book will be translated to increased deliveries from 1988 onwards.

The difference between deliveries and scrappings gives us the change in the fleet size, after allowing for losses. The dry cargo fleet is projected to fall by another 1% this year before it starts rising gradually from 1989 onwards. Our projected increase in prices is sustainable because it does not imply such a high growth rate for the fleet as will frustrate the possibilities for the long term improvement in the freight rates which is needed to justify these higher prices.

Our assumptions also imply a reduction in the proportion of combined carriers in dry. This makes the projected growth rate of the trading fleet in dry less that the growth rate of the dry cargo fleet itself. This also makes some room for an increase in dry cargo values.

Consistent with our projected immediate increase in dry cargo values are our projection of higher freight rates from 1987 onwards. Freight rates are projected to increase by 30% within 1987 and by another 22% in 1988. The higher freight rates reflect the increase in bunker prices, the increase in the growth rate of demand and the expectation of a further drop in the size of the fleet. By the early 1990s, however, the growht rate of the fleet is expected to catch up with the growth rate of demand, so that no further significant increases in rates are expected thereafter.

Scrapping is expected to increase significantly towards the end of the next decade as we expect the proportion of old dry cargo ships to rise significantly. The ageing of the fleet reflects the significant dwt of ships delivered in the '70s and early 80s. Ageing should contribute positively towards an increase in rates and values.

Our assumption of gradual increases in the demand for OPEC oil also imply a 40% increase in tanker values within 1987. These are expected to be followed by a further 20% increase in the next 2 years. As a result the scrapping rate is expected to be significantly reduced to an average of 3% p.a. of the fleet during the next 10 years. This rate is a little higher than the average scrapping rate observed in the past under similar levels of ship prices. This is a consequence of the lengthening age profile of the fleet.

In line with the increase in values we project an increase in the supply of new tankers. The order book is projected to increase to 20.1 million dwt tons by the end of 1987, and deliveries are expected to double by the mid-1990s. These projections imply that the tanker fleet will continue to decrease in the next three years and will only start rising in the beginning of the 1990s. Freight rates are expected to rise strongly within the next five years, to a 40% higher level (in $ terms) than the average over the last 6 years. However, because of the lower bunker prices, time charter rates will increase by about 80% by the mid 1990s relative to average rates in the last 6 years. This will still be 30% lower in real terms than the rates observed during the mid sixties. Similarly the prices we project for the mid nineties may be considerably higher in relation to those of the recent depression, but they still are 30% lower than those observed during the years before the 1967 closure of the Suez Canal (which in no way was a booming period).

Our forecast increases in rates and prices arrest the process of fleet reduction, which has been running at an average rate of 6.3 p.a. during the depression.

Allowing for some modest growth in demand, it is clear that rates and prices must rise considerably and soon, as the balance between supply and demand improves. Eventually the fleet must move in line with demand, which in the long run is assumed to grow by 2%. The further downward pressure on the growth rate of the fleet that arises from the ageing process, simply reinforces the need for rate and price rises. Rate and price rises work by reducing scrapping and advancing the supply of newbuildings, so that demand and supply move parallel to each other from the mid nineties onwards.

The higher the growth rate of demand is assumed to be, the sooner and stronger will the price increase have to be. Of course the outlook regarding the future path of demand is uncertain, as the fluctuations of the past decade have made clear.

Alternative scenarios: oil shocks

Our Base Run assumptions represent just one of a number of possible future scenarios, albeit the one which we think most likely to come about.

In order to explore what other possible paths future rates and prices might follow, we have re-run our model under a rather different but still plausible future scenario - one in which a sharp oil price rise occurs in 1989. The danger of an oil price hike seems remote at the moment, but will increase over the next five years, as the OPEC share in world oil supplies increases.

The effects of an oil price change on the shipping markets depends, like all other exogenous factors in our model, on whether the oil price change is expected or unexpected. Recent history suggests that unexpected changes have more dramatic and more costly effects. Our rational expectations model replicates this property, since investors can take evasive action in advance of an anticipated shock, but are by definition caught cold by an unanticipated shock. We therefore look at these two possibilities in turn.

8.2.3 Unanticipated Oil Shock

In this section we make projections regarding prices and rates under the assumption of an unanticipated oil shock.

The price rise is assumed to occur in the year 1989 and to permanently raise the price of oil to $25 per barrel (in 1987 prices). We assume that up to and including 1988 the movements in external factors and the markets' expectations regarding these, are as described in the Base Run forecast. This implies that the market moves according to our Base Run forecast up to the year 1988. The unexpected increase in the oil price is assumed to be a result of a cutback in long haul OPEC production. This reduces the demand for tanker transportation in 1989 by 16% as compared with the Base Run assumption for 1988. Tanker demand also falls by 10% in 1990 and 3% in 1991 but then grows by 2% p.a. Demand in the dry cargo market is constant in 1989, rises by 1.5% in 1990 and 3% from 1991 onwards. For the remaining exogenous variables we make the same assumptions as in the Base Run.

The implications of this scenario are shown in Tables 3 and 4. Naturally, the shock has more significant implications for the tanker market than for the dry cargo. The shock implies a significant unanticipated fall in the value of ships during the year that the shock occurs, amounting to 15% for the dry cargo ships and 32% for tankers.

These figures are much lower than the actual percentage change in values which followed the two oil shocks of the seventies. This is only because the assumed shock is of a much smaller order of magnitude (40% increase in price of oil) in comparison with the shocks of the past which led to a quadrapling of the price of oil.

In the short run freight rates are lower in comparison with the Base Run since the drop in demand outweighs the positive effect of the increase in bunker prices. The positive effect of the bunker price is permanent, however, while the effect of the lower demand disappears eventually as the stock of ships (the fleet size) adjusts to the new lower level of demand. So freight rates are actually higher in the long run under the oil shock scenario.

Time charter rates are initially 17% lower for dry cargo and 28% for tankers. However long run demand conditions are the same under both scenarios, mainly 3% growth for dry and 2% for tankers. Therefore, after the fleet adjusts to the new level of demand time charter rates and prices return to their Base Run levels.

It can be seen from the Tables that the growth rate of the fleet is much lower under this scenario than under the Base Run. The short run adjustment of the dry cargo fleet to the lower level of demand is achieved by increases in scrapping rather than reductions in deliveries, while in the tanker case adjustments in deliveries and scrappings are equally significant.

8.2.4 Anticipated Oil Shock

In this scenario, we assume that the market foresees the increase in the price of oil before it happens. Our assumptions regarding the exogenous variables in year 1987, are the same as in the Base Run. In the year 1988 we assume there is speculative stockpiling of oil, so that demand for tankers increases by 15% and the price of oil goes up to $21. In 1989 the price of oil goes up to $25 and demand for transportation is assumed to fall by 20%, both because of lower oil consumption, and because of the running down of accumulated stocks. Demand in 1990 is assumed to fall by 1% and then grows by 2% p.a. Demand in the dry cargo market rises by 3.5% in 1988, 1.5% in 1989, 2% in 1990 and from then on grows by 3% p.a.

The implications of this scenario for the tanker market are shown on Table 5. Freight rates rise strongly in 1988 because the speculative stockpiling increases the demand for transportation. Time charter rates increase significantly by the end of 1987, in anticipation of this.

However, the increase in ship values is much smaller than in the Base Run as the market foresees that the improvement is temporary. Indeed the small speculative increase in values occurs in 1987 while the stockpiling mini-boom still lies ahead. Once this is over prices are 27% lower because of the lower rates projected for 1988 onwards.

Under the assumptions of this scenario the market recovers eventually towards the Base Run level of price and rates. This recovery occurs more rapidly than it is the case in the unanticipated scenario. This is because the anticipation of the shock allows informed speculative adjustments in prices and the size of the fleet to take place early, before the shock actually occurs. This accelerates the adjustment towards the long run equilibrium.

Under all scenarios, our common assumption regarding the long run growth rate in demand, means that prices and profits will eventually recover to a particular level which is determined by this long run assumption, and which is not sensitive to the short run fluctuations in demand. This is because the fleet eventually adjusts to the level of demand and then grows in line with it, unless new shocks in demand are introduced. It is this long run growth rate of demand that determines the long run level of prices, freight market balance and rates.

Rates and prices must be strong enough in order to maintain the fleet and its growth to the level which is exogenously determined by demand. Stronger prices and rates will therefore be needed in the future to arrest the reduction of the fleet by stimulating an expansion in shipbuilding, and by reducing the scrapping rate (by extending the economic lifetime of ships).

However, the behaviour of demand in the short term is very relevant for determing the speed with which this recovery will take place. Under the Base Run scenario prices rise immediately and strongly as the balance between supply and demand can be achieved rapidly without depressed prices, and the fleet recovers quickly.

Under the alternative scenarios, there is room for prices to remain lower and for the fleet to fall with little impact on rates. It therefore takes more time for rates and prices to recover to the Base Run levels in the long run. This unambiguous long run recovery is a relative one however, in the case of tankers. Even in the long run prices and rates are still expected to be lower in real terms that what would have been expected under normal conditions before the 1970s upheaval.

Projected dry cargo rates and prices, however, compare more favourably with their normal levels in the distant past. There is still room for spectacular returns in the tanker market however because prices are still quite low.

Table 1 : The Dry Cargo Market[1] (Base Run)				
Year	Freight Rate	End Year 12 months Time Charter Rate	End Year Second Hand Prices	Mid Year Fleet Million DWT (% p.a)
1980	100.0	261	100.0	266.1 (2.70)
1981	75.3	142	62.1	276.2 (3.80)
1982	39.9	88	32.8	291.1 (5.39)
1983	38.0	102	37.9	304.5 (4.60)
1984	39.4	134	43.4	315.3 (3.55)
1985	35.1	109	30.8	325.5 (3.24)
1986	30.0	95	38.9	329.6 (1.26)
1987	39.2	144.1	60.5	326.2 (-0.8)
1988	47.9	156.2	64.1	327.3 (0.3)
1989	51.2	171.4	70.4	333.3 (1.8)
1990	54.9	180.8	75.0	342.1 (2.6)
1991	57.1	188.8	79.0	352.7 (3.1)
1992	58.8	194.2	82.6	364.3 (3.3)
1993	59.1	194.8	85.2	377.2 (3.5)
1994	58.8	196.7	86.4	390.8 (3.6)
1995	58.8	196.2	87.3	404.5 (3.5)
1996	59.0	196.5	89.1	417.4 (3.3)
1997	59.5	196.5	91.6	431.5 (3.2)
1998	60.0	198.7	96.3	445.5 (3.2)
1999	60.9	206.1	102.9	459.3 (3.1)
2000	63.2	215.5	104.1	471.9 (2.7)

1980 - 1986 Actual historical figures

1987 - 2000 Projections

Year	End Year Order Book Million DWT	Deliveries Million DWT	Scrapping Million DWT (%)	Fleet over 20 years old %
1980	36.1	10.9	2.50 (0.94)	16.2
1981	41.0	15.1	1.50 (0.54)	15.1
1982	31.2	19.0	4.00 (1.37)	15.6
1983	37.3	16.8	7.00 (2.30)	15.2
1984	32.7	20.3	9.00 (2.85)	14.3
1985	24.6	20.0	11.50 (3.53)	13.7
1986	16.6	16.0	14.70 (4.46)	13.2
1987	28.7	11.4	12.0 (3.7)	14.3
1988	34.6	13.7	7.4 (2.3)	16.1
1989	38.0	16.1	6.7 (2.0)	17.6
1990	40.2	18.0	6.1 (1.8)	19.2
1991	42.0	19.5	6.1 (1.7)	19.7
1992	44.0	20.6	6.3 (1.7)	22.3
1993	45.9	22.1	6.3 (1.7)	24.0
1994	47.2	23.2	7.1 (1.8)	24.0
1995	48.1	24.2	8.3 (2.1)	23.6
1996	49.1	25.0	9.1 (2.2)	23.2
1997	50.5	25.7	9.6 (2.2)	27.3
1998	52.9	26.6	10.1 (2.3)	27.8
1999	56.2	27.9	12.5 (2.7)	27.3
2000	59.5	29.2	14.8 (3.2)	26.6

Table 2 : The Tanker Market[2] (Base Run)				
Year	*Freight Rate*	*End Year 12 months Time Charter Rate*	*End Year Second Hand Prices*	*Mid Year Fleet Million DWT (% p.a)*
1980	*285.0*	*6.01*	*100.0*	*326.9 (-0.1)*
1981	*213.0*	*2.96*	*48.7*	*322.6 (-1.3)*
1982	*175.0*	*2.38*	*35.3*	*311.4 (-3.4)*
1983	*175.0*	*3.68*	*50.9*	*292.1 (-6.2)*
1984	*180.0*	*3.09*	*47.3*	*276.3 (-5.4)*
1985	*180.0*	*2.86*	*42.7*	*257.3 (-6.8)*
1986	*184.0*	*4.03*	*76.5*	*239.2 (-7.0)*
1987	*125.3*	*4.16*	*84.9*	*239.4 (-1.8)*
1988	*203.7*	*3.85*	*89.0*	*236.9 (-1.1)*
1989	*195.2*	*4.84*	*102.5*	*236.0 (-0.4)*
1990	*229.7*	*5.19*	*107.2*	*236.9 (0.4)*
1991	*242.9*	*5.51*	*109.7*	*239.8 (1.2)*
1992	*255.1*	*5.58*	*109.4*	*244.3 (1.9)*
1993	*259.2*	*5.46*	*107.4*	*250.3 (2.5)*
1994	*258.4*	*5.42*	*106.2*	*257.2 (2.7)*
1995	*259.9*	*5.39*	*105.6*	*264.6 (2.9)*
1996	*261.7*	*5.39*	*105.7*	*272.3 (2.9)*
1997	*265.0*	*5.42*	*106.3*	*274.7 (2.7)*
1998	*268.6*	*5.44*	*107.5*	*287.1 (2.6)*
1999	*271.7*	*5.50*	*109.7*	*295.2 (2.8)*
2000	*276.9*	*5.60*	*112.0*	*303.5 (2.8)*

1980 - 1988 Actual Historical Figures

1987 - 2000 Projections

Year	End Year Order Book Million DWT	Deliveries Million DWT	Scrapping Million DWT (%)	Fleet over 15 years old %
1980	18.3	6.99	7.71 (2.36)	14.7
1981	13.6	8.25	11.97 (3.71)	15.3
1982	9.1	6.16	21.58 (6.93)	16.0
1983	10.4	4.58	23.22 (7.95)	16.1
1984	11.3	4.19	17.49 (6.33)	15.9
1985	11.6	4.30	21.82 (8.48)	15.6
1986	13.5	7.30	12.75 (5.33)	16.6
1987	20.1	7.5	9.9 (4.1)	73.4
1988	25.1	8.2	9.4 (4.0)	73.8
1989	31.0	9.0	8.2 (3.5)	72.9
1990	36.2	10.1	7.4 (3.1)	71.7
1991	40.4	11.4	6.8 (2.8)	70.8
1992	44.1	12.6	6.5 (2.7)	68.7
1993	44.4	13.8	6.6 (2.6)	65.7
1994	44.9	14.4	6.5 (2.5)	62.6
1995	45.4	14.8	6.4 (2.4)	59.7
1996	46.1	15.1	6.8 (2.5)	57.9
1997	47.1	15.3	7.3 (2.5)	56.2
1998	47.9	15.6	7.6 (2.6)	54.8
1999	48.4	15.8	7.1 (2.4)	53.5
2000	50.1	16.1	7.0 (2.3)	52.8

Table 3 : The Dry Cargo Market (Unanticipated Oil Shock)

Year	Freight Rate	End Year 12 months Time Charter Rate	End Year Second Hand Prices	Mid Year Fleet Million DWT (% p.a)
1989	48.5	141.7	54.3	333.2 (1.8)
1990	47.6	146.7	58.1	341.0 (2.3)
1991	48.7	155.0	62.7	349.7 (2.5)
1992	50.7	161.5	66.9	359.1 (2.7)
1993	52.5	171.2	72.9	368.8 (2.7)
1994	54.9	183.1	79.9	378.6 (2.6)
1995	57.8	193.4	86.8	388.3 (2.5)
1996	60.6	200.8	92.8	398.7 (2.7)
1997	62.3	203.2	96.5	410.7 (3.0)
1998	63.2	205.2	100.5	424.1 (3.3)
1999	64.2	211.6	106.0	437.3 (3.1)
2000	66.2	220.0	111.7	450.1 (2.9)

Year	End Year Order Book Million DWT	Deliveries Million DWT	Scrapping Million DWT (%)	Fleet over 20 years old %
1989	32.6	16.1	6.8 (2.1)	17.6
1990	36.9	16.5	6.4 (1.9)	19.2
1991	40.1	18.1	7.1 (2.0)	20.0
1992	42.7	19.8	8.4 (2.3)	22.8
1993	44.8	21.2	9.4 (2.5)	24.6
1994	47.9	22.6	10.8 (2.8)	24.7
1995	51.2	24.1	12.1 (3.1)	24.4
1996	54.5	25.8	12.3 (3.1)	23.8
1997	56.7	27.6	12.1 (2.9)	27.7
1998	58.9	29.0	12.1 (2.9)	27.9
1999	61.4	30.5	14.7 (3.4)	27.0
2000	64.1	32.0	17.2 (3.8)	26.0

Table 4 : The Tanker Market (Unanticipated Oil Shock)

Year	Freight Rate	End Year 12 months Time Charter Rate	End Year Second Hand Prices	Mid Year Fleet Million DWT (% p.a)
1989	178.6	3.5	60.9	235.2 (-0.7)
1990	202.5	3.2	62.6	232.7 (-1.1)
1991	191.0	3.7	71.1	228.9 (-1.6)
1992	216.0	3.8	75.2	225.6 (-1.4)
1993	222.7	4.2	80.0	223.6 (-0.9)
1994	236.2	4.3	83.7	223.1 (-0.2)
1995	244.7	4.5	87.5	224.3 (0.5)
1996	255.1	4.7	90.9	226.5 (1.0)
1997	263.7	4.8	94.2	229.3 (1.2)
1998	272.3	5.0	97.0	232.3 (1.3)
1999	279.2	5.1	100.0	236.3 (1.7)
2000	286.6	5.2	103.3	241.2 (2.1)

Year	End Year Order Book Million DWT	Deliveries Million DWT	Scrapping Million DWT (%)	Fleet over 15 years old %
1989	22.6	9.0	9.7 (4.1)	72.8
1990	23.8	8.6	11.8 (5.1)	71.8
1991	25.6	8.6	11.8 (5.2)	71.2
1992	28.7	8.9	11.0 (4.9)	69.5
1993	31.4	9.5	10.1 (4.5)	67.1
1994	34.1	10.2	9.2 (4.1)	64.3
1995	36.1	11.0	8.5 (3.8)	61.6
1996	37.3	11.7	8.5 (3.8)	60.0
1997	38.0	12.2	8.7 (3.8)	58.4
1998	38.9	12.7	8.8 (3.8)	57.0
1999	39.6	13.0	7.8 (3.3)	56.0
2000	41.2	13.3	7.4 (3.1)	55.0

Table 5 : The Tanker Market (Anticipated Oil Shock)

Year	Freight Rate	End Year 12 months Time Charter Rate	End Year Second Hand Prices	Mid Year Fleet Million DWT (% p.a)
1987	125.8	5.6	68.4	238.9 (-2.0)
1988	257.1	2.5	53.5	234.1 (-2.0)
1989	161.7	3.7	67.8	228.2 (-2.5)
1990	210.2	3.4	70.0	227.9 (-2.7)
1991	201.2	4.1	78.5	216.4 (-2.5)
1992	229.7	4.1	81.5	212.6 (-1.8)
1993	232.6	4.5	85.9	210.7 (-0.9)
1994	247.0	4.6	88.2	210.6 (0.9)
1995	253.0	4.7	90.8	212.3 (0.8)
1996	261.8	4.8	93.1	215.4 (1.4)
1997	268.4	4.9	95.5	219.2 (1.7)
1998	275.7	5.0	97.9	223.5 (1.9)
1999	281.6	5.1	100.7	228.4 (2.2)
2000	288.3	5.3	103.8	234.3 (2.5)

Year	End Year Order Book Million DWT	Deliveries Million DWT	Scrapping Million DWT (%)	Fleet over 15 years old %
1987	15.0	7.5	10.9 (4.6)	73.4
1988	15.8	7.0	12.0 (5.1)	77.4
1989	17.5	6.6	12.2 (5.4)	73.5
1990	20.6	6.6	12.4 (5.6)	72.9
1991	24.2	7.1	11.3 (5.2)	72.7
1992	28.3	7.9	10.2 (4.8)	71.4
1993	31.3	8.9	9.4 (4.5)	69.1
1994	34.5	10.0	8.5 (4.0)	66.3
1995	37.5	10.9	7.8 (3.7)	63.5
1996	40.0	11.9	7.8 (3.6)	61.8
1997	41.7	12.8	8.0 (3.6)	60.1
1998	42.5	13.5	8.3 (3.7)	58.0
1999	42.5	13.8	7.4 (3.2)	55.8
2000	42.7	14.1	7.2 (3.1)	53.8

CHAPTER 9

CONCLUSIONS

This chapter summarises the main topics analysed and the results presented in this thesis. It reviews the novel features of our theory and their implications. It also describes the main results of the empirical work. It concludes with recommendations about how future research could proceed along the lines of the theoretical framework we have developed.

9.1 Conclusions

The main objective of this thesis has been to explain how equilibrium freight rates, ship prices, shipbuilding and scrapping are determined in terms of the exogenous impulses and the interactions among the freight market and the markets for vessels.

9.1.1 A 'new' theory

In order to model the way that rates, prices, shipbuilding and scrapping are determined, a new theory of the shipping markets has been presented and based on this, econometric models of the dry cargo and tanker market have been specified and estimated.

The theory distinguishes between the freight, second hand, newbuilding and scrapping markets. For each market, aggregate demand and supply relationships were specified. These were derived as solutions to constrained maximisation problems of economic agents, rather than being ad hoc specifications.

Novel features of the theory are, first, the treatment of new and second hand ships as capital assets and, secondly, the assumption of rational expectations. According to the capital asset approach, the demand for existing ships is specified to depend on the return on ships relative to the available returns on other investments. This implies that at equilibrium the price of ships moves to a level where the return on ships is equal to the return on other assets after allowing for risk.

The capital asset approach also revolutionizes the problem of specifying a demand for newbuildings function. The specification of the newbuilding demand has been the weakest and theoretically least satisfactory part of existing econometric models of the shipping industry, in spite of its central importance. Our theory suggests that newbuilding construction (investment) is determined from the supply side in terms of the amount of ships that builders wish to supply at the equilibrium price which investors are prepared to pay. Demand for newbuildings is infinetely elastic at the equilibrium price. A small change in price is sufficient to turn an expensive newbuilding asset into a bargain, generating a tendency for massive capital inflows/outflows that prevents the price from deviating from its equilibrium level.

In previous work, the problem of specifying second hand and newbuilding functions had been compounded by the inappropriate treatment of expectations. These had, typically, been assumed to be extrapolations of recent and longer term trends. Instead, we have modelled expectations according to the rational expectations hypothesis. This endogeneises expectations by assuming they are the same as the predictions of the model. The rational expectations hypothesis differs fundamentally from the alternative (e.g adaptive) expectations generating mechanisms. It has novel implications about how investment and equilibrium prices of newbuilding/second hand ships are determined in the asset markets. The rational expectations hypothesis creates speculative forward looking links in the model between the current ship markets and the future markets for freight and ships. This illuminates the role of speculation and explains real world phenomena that alternative theories do not. In particular, the role of 'news' and how these can cause speculative jumps in values and overshooting phenomena are clearly illustrated. It allows us to distinguish between anticipated and unanticipated shocks and to simulate the response of the market to each of these types of shocks.

The results of these simulations indicate that freight rates, ship values, shipbuilding and scrapping overshoot their long run equilibrium in response to a demand or bunker price shock. In the short run the fleet is fixed, so the maximum effect on rates occurs at the time of impact. In anticipation of the sluggish response of the fleet, there is a strong short term response in values. The increase in values leads to a shipbuilding boom and a parallel decrease in scrapping. These cause the fleet to rise gradually so freight rates and prices begin to ease. As values fall, shipbuilding and scrapping also begin to return to normal levels until the system makes a soft landing to a new long run equilibrium.

In contrast to demand and bunker price shocks, freight rates and prices tend to undershoot their new long run equilbirium level when a shipbuilding cost shock occurs. This is because this shock has no direct impact on the freight market. The effect of this shock comes through the ship markets. The shock has a gradual effect on the size of the fleet which in turn begins to affect freight rates. In anticipation of this, there is small initial response in ship prices. As the changes in the fleet size are accumulated freight rates and prices increase further. Eventually prices move to such an extent that this completely cancels out the initial restraint of higher costs on shipbuilding. Fleet and demand grow in line with each other again. In the meantime the fleet growth has lagged behind that of demand so there is a permanent improvement in market balance, freight rates and ship values.

The simulated response of the market to an unanticipated demand shock, exhibits cyclical features which are similar to those of a real world cycle. The latter were described in chapter 1. There, it was found that freight rates, time charter rates, prices, shipbuilding and fleet growth move procyclically. They also move in phase with rates except for shipbuilding and fleet growth which tend to lag behind rates by a year or so. On the other hand, lay-up and scrapping move countercyclically and also in phase with rates. These correlations in rates, values and fleet changes were replicated by the theoretical model's simulations of the effects of an unanticipated demand shock. We can say, therefore, that our model provides a theoretical explanation of the phenomenon of the shipping cycle.

9.1.2 The econometric models

In chapter 4, 5 the theoretical model was used as a basis in order to specify and estimate econometric models of the world dry cargo and tanker markets respectively. Aggregate demand and supply functions were specified for the freight, second hand, newbuilding and scrapping markets. These were estimated from post World War II data.

The empirical results were consistent with a priori views regarding the sign and magnitude of various elasticities. Supply in the freight market was found to be very inelastic at low levels of lay-up. This was estimated to be 0.24 for the dry cargo market and 0.31 for the tanker market. These results are consistent with the findings of other studies applied to, not only post war, but also to 19th century and early 20th century data. However, supply is very elastic at depressed freight rates where lay-up is high. There, a small increase in rates will induce a large number of ships to break lay-up and thus supply responds strongly.

Supply of new ships was found to be more elastic than the freight market supply. The long run elasticity of the dry cargo order book with respect to prices was found to be 0.77 while that of the tanker order book was found to be 2.38. In the short run, however, supply of newbuilding is completely inelastic as deliveries are predetermined in terms of past orders. Supply was also found to be inversely related to the price of the alternative ship type. Thus, supply of dry cargo newbuildings is negatively affected by the price of tanker newbuildings and vice versa.

The equilbrium price of ships was found to be positively related to expected short term profitability and expected capital gains. The elasticity with respect to the former was found to be much lower than that with respect to the latter. This is not surprising since ships are assets of considerable longevity. For dry cargo ships, the elasticity of prices with respect to short term profits was found to be 0.27 and that with respect to expected capital gains was estimated to be 0.73. The corresponding figures for tankers were 0.29 and 0.71 respectively. The estimated $\bar{R}^2$ of the empirical inverted asset demand functions were found to be very high indeed. The results give strong support to the capital asset approach we have adopted.

The supply of ships for scrap was found to be inversely related to the price of ships relative to the price of scrap. Scrapping is also much lower within the younger age groups than within the older ones. When the market is strong, scrapping of young ships virtually drops to zero. However, scrapping of young ships becomes more significant during the depression. For example, at the bottom of the depression there is 1.9% tanker scrapping in the 10-15 years old age group, 12% in the 15-20 years old age group and 21% in the 20 years and over group. On the other hand, at the peak of the boom these figures drop to 0.2%, 1.4% and 3.2% respectively.

The empirical models were used in order to simulate the response of the system to various anticipated and unanticipated external shocks. The qualitative results were found to be similar to those derived by simulations of the theoretical model. However, simulations of the empirical models allowed us to determine the magnitude of the response as well. Because supply of freight is inelastic, demand and bunker shocks have a very strong impact effect on freight rates. Prices also respond strongly to the anticipated improvement in the profit profile. Because supply of newbuildings is fairly elastic, the fleet adjusts quite rapidly to any short term shortage in the freight market. The increase in prices leads to a shipbuilding boom and a parallel drop in scrapping. This helps to eliminate the shortage and within a relatively short period of time the market approaches its long run equilibrium.

The dry cargo freight market submodel was also used in order to perform historical simulations. These tracked the actual historical movements very accurately. Standard measures of simulation performance were calculated and these were found to be very satisfactory. These simulations illustrate the usefulness of the aggregate approach. The significant oscillations in rates over a period of 25 years were accuratelly explained in terms of the aggregate freight market balance, fuel prices and operating costs.

In chapter 6 the dry cargo and tanker models were linked together. For this purpose, the behaviour of the combined carrier fleet had to be modelled. The integration of the tanker and dry cargo sectors allowed us to calculate the spillover effects from one market to the other. The effects of an increase in tanker demand on the dry cargo market and vice versa were calculated. It was seen that an increase in, say, the demand for tanker freight services leads to an increase in dry cargo rates and prices as well. This is because of various freight and ship market links between the various sectors.

These links are the following: In the freight market combined carriers will switch from the tanker to the dry cargo sector depending on relative freight rates. In the shipbuilding market supply of dry cargo ships, say, is negatively related to tanker prices. In the scrap market, total demand for scrap is satisfied by tanker and dry cargo supply of ships for scrap.

These links imply that an increase in tanker demand will spillover to the dry market and vice versa. The higher tanker demand will lead to an increase in tanker rates which will attract combined carriers to oil. This will reduce the supply in the dry sector so dry cargo freight rates will also improve. At the same time the strengthening of tanker prices will lead to an increase in tanker supply partly at the expense of dry cargo newbuilding supply. This restrains the growth rate of the dry cargo fleet which leads to further improvements in rates and prices. In the scrap market, the improvement in tanker values leads to a reduction in the supply of tankers for scrap. This reduces the total supply of ships for scrap and thus scrap prices increase. This in turn creates an incentive to scrap other ship types so the supply of dry cargo ships for scrap increases so as to fill the gap that is left by the withdrawal of tankers from the demolition market.

9.1.3 Testing the rational expectations hypothesis

In chapter 7 we tested the assumption of rational expectations in the shipping markets. This was one of the crucial and distinguishing assumptions of our model. The assumption was separetely tested in the freight futures, time charter and newbuilding markets. The test results were consistent with the assumption of rational expectations in the time charter markets. However the test results for the freight futures and newbuilding markets often rejected the implications of EMH/RE hypothesis.

These negative results do not necessarily imply rejection of the rational expectations hypothesis. This is because the RE assumption has been imbeded within the EMH. A negative result might be due to failure of the latter rather than the former. More importantly perhaps, the implicit assumption that observable freight futures and newbuilding prices are market clearing prices is somewhat suspect. In the case of freight futures, we have the distorting influence of limit moves. In the case of newbuildings we have a similar constraint in the movement of prices. When the market becomes depressed, newbuilding prices seem to adjust in a sluggish way as yards prefer to work on their existing order books rather than arrange new orders by offering competitive prices.

9.1.4 Forecasts

In chapter 8 we used the model in order to generate forecasts of the dry cargo and tanker markets up to the end of the 1990s. These indicate that the recent improvement in market conditions is largely permanent. The severe depression of the early 1980s was an extreme one off event which was intensified by the unforeseen nature of the oil shocks which caused it. The stock adjustments in shipbuilding and scrapping capacity and the size of the fleet which have already occured, together with the expected mild growth in demand support the higher level of prices and freight rates that have been seen recently.

9.2 Recommendations for future research

Our results have illustrated the usefulness of the rational expectations hypothesis and the capital asset approach to the modelling of ship markets. The capital asset approach was found to be empirically acceptable and much more satisfactory than alternative specifications. Unlike other specifications, it is also consistent with the axioms of rationality. These observations suggest that future modelling of the demand for newbuilding and second hand ships should proceed along these lines.

The rational expectations hypothesis was usefully exploited to explain real world phenomena such as overshooting of freight rates, prices etc., the role of speculation and the influence of 'news'. The validity of the rational expectations hypothesis was tested in chapter 7. The evidence supported the RE hypothesis in the time charter markets. The results for the futures markets were mixed while for the newbuilding market the tests tended to reject the EMH/RE hypothesis. For reasons already discussed, these results cannot conclusively reject the RE hypothesis.

Even if it could be shown that the rational expectations hypothesis in the shipping markets is not strictly true, it would still be desirable, in future research, to model expectations in a more forward looking way than what has been the case in the past. The possibly extreme version of rational expectations is a useful starting point.

Disaggregation

The theoretical framework used for modelling the freight, second hand, newbuilding and scrapping markets has produced satisfactory results. These suggest that future research might benefit by proceeding within the guidelines of our general theoretical framework. The theoretical framework can straightforwardly, and without any major conceptual modification, be used for disaggregated modelling of the shipping markets. Whether this is desirable is debatable. The answer to this question depends, of course, on an evaluation of the costs and benefits of such an extension. In theory there are some good reasons for disaggregation. At the same time there is a combination of theoretical and practical (e.g. data availability) factors that argue against disaggregation. In any case, the following paragraphs illustrate how disaggregation can be achieved within the theoretical framework developed in chapters 3, 4.

For example, in the case of tankers it might be desirable to distinguish between smaller and larger tankers since these are not perfectly substitutable. This would require a separate specification of a freight market for small and large ships. Both the demand and supply sides of the two markets are highly interdependent. Demand for various vessel types is interdependent because there are routes where many vessel types can operate. Their services are highly substitutable in these routes. However, there are other routes where large vessels cannot operate because of draft restrictions.

We can model the supply side of the dissagregate freight market along the following lines. Supply generated by each ship type should be proportional to the size of the fleet and should be positively related to freight rates but negatively related to fuel prices and operating costs. The influence of combined carriers should also be taken into account. These extensions seem to be feasible on the basis of the available data.

Turning to the ship markets, separate asset demand functions for small and large tankers could be specified as in chapters 4 and 5. On the newbuilding market, the supply of small tankers would in theory be positively related to prices of small tankers and negatively related to the price of other ship types such as large tankers and dry cargo ships. Similarly for large tankers. Individual scrapping supply equations could be easily specified as in chapters 4 and 5. For example, the supply of small tankers for scrap generated by a particular age group should reflect the price of small ships relative to scrap prices. Similarly for large tankers. These extensions also seem to be feasible on the basis of available data.

In the dry cargo markets there are theoretical reasons to suggest that we should distinguish between bulk and general cargo ships and also between the competitive tramp and the oligopolistic liner business. Again, here, the theoretical framework can be straightforwardly be used in order to specify separate and possibly interdependent demand and supply functions in the individual freight, second hand, newbuilding and scrapping markets. However in this case it becomes much more difficult to separate the various sectors both in theory and from the data.

Supply of new ships and newbuilding prices

The results of chapter 7 cast some doubt on the validity of the joint hypothesis of efficient markets and rational expectations. Our interpretation of these negative results was that these are mainly due to the fact that the quoted newbuilding price cannot always be interpreted as a market price. Such a situation usually occurs during an unexpected depression. There, prices of new existing ships can drop to levels where they do not cover the cost of shipbuilding even after allowing for subsidy. During such periods shipbuilders prefer to work on their existing orders which have been contracted at higher past prices. There is little incentive to arrange for new orders until the existing order book is sufficiently depleted and thus no incentive to offer acceptable prices to investors. This implies that the quoted prices cannot be interpreted as market prices unless sufficient contracts have been signed by investors at these prices. Even after the order book has been depleted, the quoted newbuilding price of ships might still not move down to level suggested by the theory. If market prices of new ships are still far below the shipbuilding cost then builders cannot offer these prices. The quoted newbuilding price tends to reflect the cost of shipbuilding. At the same time, during such periods of prolonged depression, new order contracts seem to be accompanied by a number of cheap finance, subsidy and other clauses which reduce the 'effective newbuilding price' paid by the investor and received by the builder. It is this latter unobservable 'effective newbuilding price' which determines market behaviour and not the unrepresentative quoted price.

These negative results do not invalidate our theoretical framework. Our theory is still valid, albeit in terms of the unobservable 'effective newbuilding price' rather than the 'quoted newbuilding price'. The 'quoted newbuilding price' has always been used in past research as the relevant price mainly because of the lack of data on unobservable 'effective newbuilding prices'. However, the above remarks suggest that future modelling of newbuilding markets would benefit by the construction of measures of 'effective newbuilding prices' to be used in place of 'quoted newbuilding prices' which should be disregarded since these are not market prices.

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