FORECASTING TANKER FREIGHT RATES

by

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Abstract

The object of this thesis is the explanation and prediction of the freight rates that prevail in the tanker market. The investigation is conducted in three steps: The demanded tanker capacity is studied first, then the available tanker fleet and finally the prevailing freight rates. The analytical tool used in the thesis is linear regression analysis. The collected data covers a period of 10 years (Jan. 1983 - Dec. 1992). The first study establishes that the industrial production of the most industrialized countries has a high explanatory power when demanded transportation capacity is the explained variable. Gross National Product is also investigated as an explanatory variable. The second study establishes the relation between scrappage rate and past prevailing freight rates. The explanatory power of the age of fleet is also investigated. The third study explores the relation between tanker availability, tanker demand and freight rates. The resulting relations from the three studies are integrated in a program for forecasting tanker freight rates. Finally the predicted values generated by the program are presented, covering the period of the next two years.

Thesis Supervisor: Henry S. Marcus
Title: Professor of Marine Systems

Στούς Γονείς μου

Θεοδώρα και Μιχάλη

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Chapter 1

Introduction

1.1 The Model

A computer model describing and predicting tanker market behavior is an indispensable tool for everyone that wants to deeply understand this market. Many analyses on this field have already been published. However, since the tanker market is in a continuous changing mode, an updated analysis is necessary.

New technologies introduced in shipbuilding, changes in the opinion of shipowners on how large ships should be, the attitude of their clients chartering ships for smaller periods of time, the deepening of ports and the widening of channels, as well as new oil consuming and producing areas resulting in the emergence of new trade routes are some of the factors that make the tanker market change every day.

Finally, those who were reluctant to announce the "end of history" during the early 90's and supported the idea that markets would never lose their equilibrium due to uncertainty, were proved wrong just 18 months later when Iraq invaded Kuwait, causing freight rates to triple and thus closing one more cycle [1] of the oil tanker market. More information on how the market mechanisms work and from what it is influenced, the main futures that characterize tankers and their impact on economic decisions (expected freight rate for the particular vessel), from both charters and shipowners, will be given in Chapter 1, section 2.

Although the tanker market is characterized by a continuously changing structure, the

[1] A cycle in tanker market is the period between two "booms" . These "booms" last a few months and freight rates are 3 and more times higher than those experienced in an equilibrium market.

main rules on how the tanker market functions and the main factors that influence it stay the same. A brief look on previous investigations that describe and validate these rules is done in Chapter 1 , section 3.

Despite the difficulties that were introduced by the changing nature of tanker market, the development of new ways of obtaining information allowed us to gather enough market data covering the past 10 years (1983 - 1993). Also, using regression analysis as a mathematical tool, a satisfactory degree of analysis was achieved, thus revealing the mechanisms that characterize the function of this market. A brief review on regression analysis as a mathematical tool will be given at Chapter 1, section 4.

In this thesis, having understood the market mechanisms, a model will be developed. The model will analyze tanker demand for the past 10 years (Chapter 2, section 2). Tanker demand will be expressed in terms of the industrial production index of the most industrialized countries, allowing us to project it to the future.

Tanker availability will be discussed in Chapter 2, section 3. Scrappage rate categorized by size will be investigated and its relation with spot rates and age of the fleet will be retrieved. Then, in Chapter 2, section 4, we will define freight rates in the spot market as a relation of tanker availability and tanker demand. All the above factors that define the tanker market behavior will be combined, thus forming our model. A validation of the model will be performed by comparing the actual data for the period of June 1993 - May 1994 with the ones predicted by the developed model.

Having derived formulas projecting tanker demand (assuming industrial production index known) and tanker availability (assuming that we know the scheduled deliveries for the next 2 years and using our conclusions from our investigation on scrappage rates), we will try to forecast freight rates for the next two years. Three different scenarios will be assumed on what will be the industrial production of the U.S.A., Japan and O.E.C.D. The best, mediocre and worst scenarios will define the sensitivity of tanker freight rates on tanker demand. (Chapter 2 , section 5). Also suggestions for future developments of the model will be given (Chapter 2, section 6).

Finally, in Chapter 3, the conclusions of our investigations will be given.

1.2 Elements of the Tanker Market.

The following is a brief description of specific aspects of the tanker market. They are given as an attempt to define the mechanics of this market and the factors that influence it in a qualitative sense.

- **Ships in spot market** constitute the 90% of the total capacity, in contrast with what was happening in 70's, where the 85% of the tonnage was under long-term chartering. Also 68% of the fleet capacity is owned by independent owners (and not by big oil companies).

- **Political instability** : The Middle East, one of the most unstable region on Earth, contains the largest portion of oil resources that can be exploited. Political events, such as war, naturally affect oil prices and freight rates. A few examples follow:

  1. Oil crisis of 1974 : In the three-year period up to the emergence of the effects of the first oil crisis in 1974, world seaborne oil movements grew at an annual rate of 7.0% . In 1975 there was a decline of 7%. There then followed a four-year period when growth averaged 5.0% p.a.

  2. Oil crisis of 1979-1983 : The decline in oil demand was greater and more prolonged than almost all forecasters had predicted.

  3. Iraq-Iran war : There was an unusual peak in the middle of 1984 which was brought about by the increase in hostilities between Iran and Iraq in the Gulf. We may perceive by looking at freight rates in the spot market that they climb passed break-even levels. This may have been so, but it should be noted that the voyage costs do not include any extra war risk insurance which may have been paid by the owner.

  4. Iraq-Kuwait War : In 1992 Iraq invaded Kuwait, directly controlling by this action 20% of OPEC production and 20% of world oil reserves. Attributed to the disruption and the embargo, four million barrels of oil per day were abruptly removed from the world oil market. The sharp price rise of oil was driven not only by the supply lost itself , but also by anxiety and fear for the future.

When, in late September 1990 Hussein threatened to destroy the Saudi petroleum supply system, prices in the system market leaped toward $40 per barrel, more than double what they had been before crisis. The high prices reinforced recessionary trends in the U.S. economy.

By December 1990, the lost production had been completely compensated by increased production of other sources. Saudi Arabia alone brought three million barrels per day into production. At the same time, demand was weakening, as the United States and other countries headed into economic recession, which reduced the demand of oil.

- **Slow steaming** : Voyage costs may be reduced by slow-steaming by 4.4% per ton of cargo (for a medium-sized tanker 90 - 175,000 DWT) . This tactic was followed in the early 1980's, when the market was depressed and shipowners cut ship's speed down to 11 knots from the designed one of 15.9 knots. Slow-steaming reduces the number of voyages per annum to a lesser extent on the shorter routes trade, and therefore gross revenues are less adversely affected in these trades.

- **Technological improvements** : After 1980, a new generation of fuel-efficient tankers was introduced. Higher degree of automation diminished operation costs. Finally, the new generation tankers were able to carry both crude oil and refined products.

- **Competition in other markets** (from other ship sizes) : Specially during times of low rates, tankers do not operate in precisely defined markets from which all other sizes are excluded. This is particularly the case for medium - sized tankers. They may be found operating in routes where limited port facilities would normally dictate the use of much smaller ships, or loading from ports where the great majority of crude oil exports could be lifted by the much larger VLCC's [2].

- **Suez Canal** : Limitation in draft obliges a 250,000 DWT tanker (VLCC), fully laden to go around Cape of Good Hope. In its return (under ballast), it may go through Suez Canal. On the other hand, a 120,000 tons tanker may go through Suez Canal both ways (fully laden and in ballast in its return). There is no schedule to further develop the Suez Canal, to handle fully ladden VLCC's. A rough estimation of Suez Canal traffic is 62.1 million tons of oil. Restrictions: Draft (T) <18.29m .

- **Panama Canal** : Similar to Suez Canal, it presents some restrictions on the size of the ship that is able to go through it. Restrictions: Length (L)<290 m, Beam (B)<32.3 m (106 ft), Draft (T)<13 m . Optimized ship designs for Panama Canal crossing, carrying the maximum possible cargo and giving less importance to hull resistance formed a special class of ships, the Panamax.

- **Economy of scale** : Larger tankers mean less operating costs per transported ton. This advantage may be lost by the inflexibility of larger tankers due to their greater draft and the greater difficulty of finding full cargoes.

- **Other ship characteristics** : Apart from the above characteristics (size - economy of scale, draft and beam - access in ports and Canals), additional ship characteristics that influence its utilization and profitability per voyage , are:

  1. Speed : In general, the faster the ship, the more oil it can deliver. Optimum speed for each voyage depends upon operational costs, the price of fuel being the driving factor, ship's loading condition, market conditions (crew salaries, freight rates), ship's resistance characteristics etc.

  2. Power plant: The main categories of power plants in tankers are two : diesel engines and steam turbines. As the latter presents higher maintenance and acquisition cost and lower efficiency, and technology advances offers the option of high-output diesels , most of newbuildings are equipped with a diesel propulsion plant.

  3. Pumping capability: Capacity of ship's pumps to load/unload oil. It is proportional to the time the ship has to spend in harbor (and pay port fees).

  4. Flag of convenience : during the recession years (after 1979) most of shipowners did not even achieved break-even freights, but there are also many owners of Convenience flag tonnage with very low operating costs who would, therefore, may have been in a better than break-even position. For a 70,000 DWT tanker (PANAMAX size), changing its flag to a Convenience flag, would have caused in 1993 a reduction of 13% on its operating costs (from 3,700 U.S.$/d down to 3,230 U.S.$/d).

- **Newbuilding Market** : In the early 70's newbuilding prices were fairly stable at about $15 million for a tanker of just under 100,000 dwt and about $20 million for one of 150,000 dwt. The massive ordering boom of VLCC's in 1972 and 1973 also forced prices sharply higher for medium-sized tankers. Between 1971 and the end of 1973 the rise in price was 40%-50%.

  The virtual halt in ordering which followed, and cancellation of many orders, brought about a reversal of prices, but only to levels which were still 25%-30% above 1971 levels.

  The next surge in ordering occurred in 1979/80, and by the end of 1980 prices had risen by 100%-150% from their 1975 levels and were about three times their 1971 levels.

  During the period 1980-85 there has been little contracting of medium-sized tanker newbuildings, and prices have fallen by more than 40% from their peak 1980 levels. The downward pressure on prices caused by low ordering levels has been increased recently by competition to the historically dominant Japanese yards from builders in low-cost countries such as Korea, Taiwan and China. Prices for combined carriers have normally been some 5%-10% higher than those for tankers, although the premium at times has been as much as 20% (in 1977 and 1980) and even 25%-30% (1975/76).

- **Secondhand Market** : The peaks in sale and purchase activity have generally occurred at times of rising secondhand prices : 1972/3, 1976, 1979/80 and late 1983. In both 1972 and 1973 over 3% of the fleet was sold, compared with less than one per cent in 1971 and 1974. In the early 1980's between 5.5% and 7.5% were sold each peak year, compared with three to four per cent in other years. Prices fluctuate enormously. At the end of 1976 a five year old ship of 135,000 dwt could be sold for around $14 million, having risen from $10 million at the beginning of the year. In the depressed markets of 1977/78 the price fell back to below $10 million. Then, through the next two years, there was a steady rise up to almost $20 million. By mid-1983, however, prices had fallen to between $11 and $12 million.

- **Types of freights** : The following types of chartering exist in the tanker market:

1. Single-Voyage: The vessel is hired to move cargo from one port to another for only one voyage and on specific dates. Shipowner pays all the operation costs of the ship.
2. Consecutive-Voyage: As above, shipowner pays all the operation costs of the ship, only the chartering is for a series of successive voyages.
3. Time Charter: Ship is hired for a period of time, usually one to three years. Maintenance costs and crew salaries are paid by the shipowner. Fuel and port fees are paid by the charterer. The charterer has the operational control of the ship which he may use as he pleases, within the limits of maritime prudence and safe navigation. Charterer is obliged to return the ship to its owner for a number of days each year for the sake of proper maintenance. The number of days are pre-arranged and the shipowner is not paid during this period (off-hired period). The charterer may relet the ship. Also the agreement specifies the fuel consumption of the ship at its service speed. If this is exceeded, shipowner has to pay compensation. If this is less than the expected, shipowner may be refunded. Therefore, the risk of performance of the vessel goes to the owner and the risk of change in fuel oil prices goes to the charterer.
4. Contract of Affreightment: a shipowner accepts the obligation of transporting a certain amount of oil from one port to another in a specific time period. He may use whatever ships he likes. Usually oil is delivered on a monthly basis, with some flexibility allowed, provided that at the end of the time period, the full amount will have been delivered.
5. Bareboat charter: Shipowner provides to the charterer only the ship, without crew, fuel or stores. Operational and maintenance responsibility is on the charterer. Usually bareboat chartering agreements refer to extended time periods.

- **Strategic Petroleum Reserve** : United States created in the middle 1970's a huge reserve of 600 million barrels of oil, to be used to flood market with oil in an event of "physical shortage" or to head off a major price spike.

- **Deadfreight** : refers to cargo-carrying capacity not used. Deadfreight is only avoidable if oil supplies can be guaranteed and if the ships available conform (in terms of draft) to the facilities at the load and discharge ports. In theory, oil supply reliability could be restored but the compatibility of ships and ports will only be gradually improved as shallow draft ships replace deeper draft ships in the fleet and as port facilities are improved. The larger deadfreight percentage has been observed to the routes N.Europe-N.Europe and routes with discharge terminal in S.Europe, specially those coming from N.Africa. This reflect the limitation in draft of ports in those areas (specially in Italy)[2]. Although deadfreight is a function of tanker's size, the medium size tankers (90,000-175,000) have experienced the larger deadfreight percentage among the tanker fleet as a whole.

[2]See Appendices A and B.

1.3 Literature Review

1.3.1 Koopmans

One of the first theories proposed to forecast tanker freight rates was introduced by Koopmans [1]. He used the traditional microeconomic theory, according to which the equilibrium point on supply - demand curves (point of intersection of these two curves) defines the prevailing freight rate. Koopmans also investigated the interrelationship between the dynamic behavior of the tanker market and tanker freight and shipyard's activity to explain the dynamic behavior of the tanker market.

Tanker demand was modeled as a market under pure competition conditions. Here it should be noted that Koopmans observed the low elasticity of the demand (low correlation between freight rates and demand for tanker transportation capacity). The above conclusion was derived by two facts:

- Oil demand itself is price inelastic, at least in the short -run. The needed oil for the industry section can not be substituted. Use of alternative fuel sources requires high capital investment and introduces inactive time for the specific industry till the modification will be over. Therefore oil consumption may be considered insensitive towards oil prices.

- Freight rates constitute only a small portion of the final product price.Therefore big oil companies generally do not consider the trends of freights but only their needs when they schedule their tankship services.

Tanker supply was also modeled as a market under pure competition conditions with the exception where the market is in a "boom" and freight rates are extremely high. In such cases uncertainty drives freight rates up, diverging the market behavior from the "perfect market model".

Koopmans, in his market model, distinguished two regions of different behavior of elasticity of supply.

- When almost all the available world fleet is chartered and the rates are high, this region shows small elasticity. More transportation capacity cannot be achieved from newbuildings as it takes two years (on average) for a ship to be built and enter the

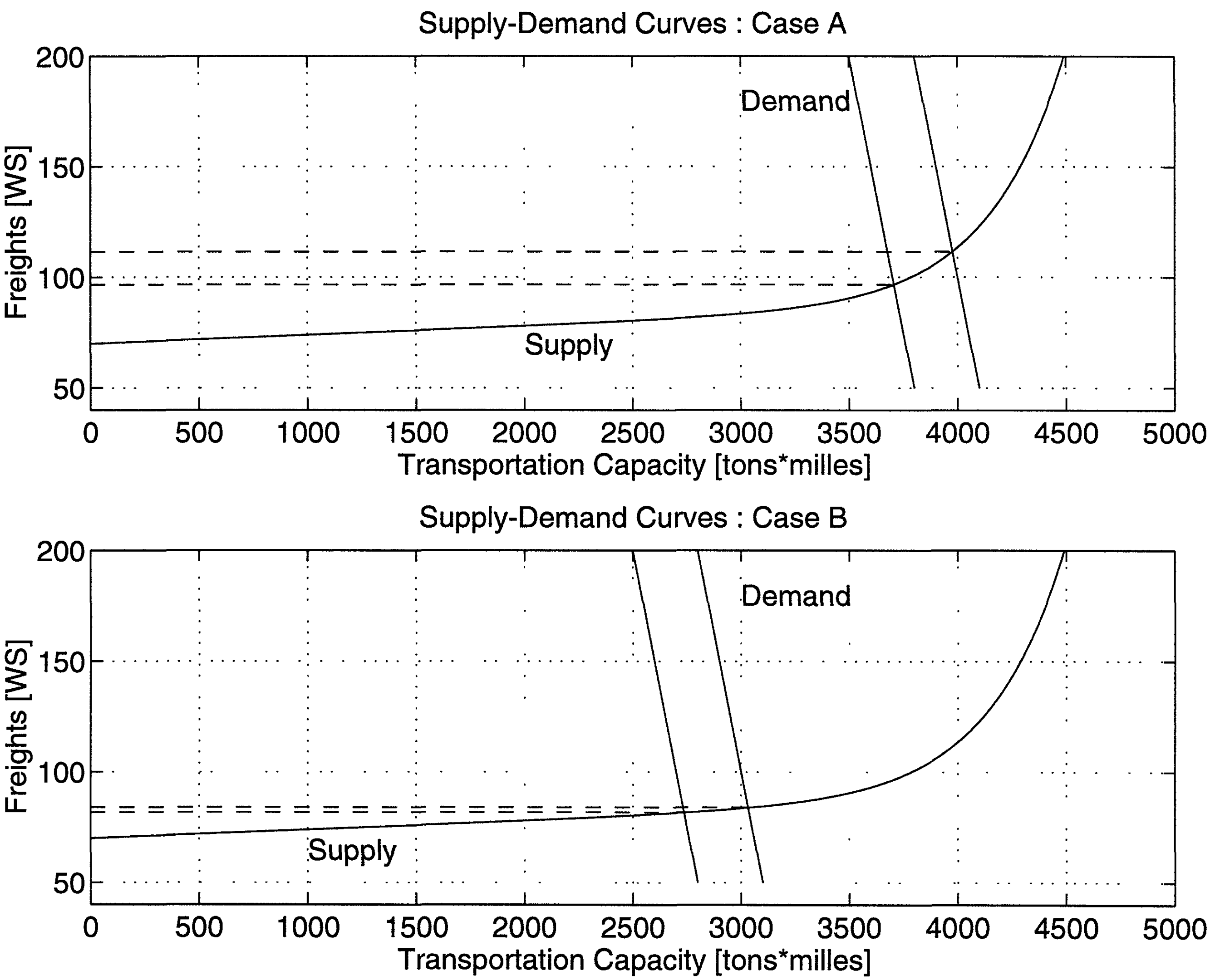


Figure 1-1: Koopmans : Different Elasticity Regions

market. Only a small amount of elasticity may be provided by increasing vessel speed and decreasing port time, thus increasing transportation capacity.

- On the other side, when many vessels are idle (laid - up or unemployed) and freights are low, tanker supply shows high elasticity. A slight increase in freight rates will drive many ships to enter the market, thus providing a large increase of transportation capacity.

1.3.2 Zannetos

Another approach adopted by Zenon Zannetos was that tanker market contains itself most of the information needed to predict future. Evaluating a methodology to forecast long-term charter rates, he used as a basis for his model short-term charter rates at the point of transaction. Before using short-term rates he divorced them from any short run fluctuations that do not reflect basic structural relationships that are not valid over time and may reflect market imperfections. Then he used correcting parameters to express long term freight rates as a function of short term rates.

In all his studies both linear and exponential regression analysis were used. The general form of relationships were:

$$R_L = R_s + a * X_1 + b * X_2 + c * X_3 + d * X_4 + ...$$

and

$$R_L = R_s * X_1^a * X_2^b * X_3^c * X_4^d * ...$$

A first approach was made in late 1950's [3]. Data covered the period between 1950 and 1957. As explanatory variables were used:

1. X_1 : The short term rate (a weighted average of spot rate on various routes weighted on the basis of quantities of crude transported).
2. X_2 : Duration of time charter in months.
3. X_3 : Lead time between agreement signature and delivery of the ship.
4. X_4 : Size of the ship in DWT.
5. X_5 : Index of short term "adjustment".
6. X_6 : Vessels idle as a percentage of the working tanker fleet.
7. X_7 : Index of change in X_6 .
8. X_8 : Orders outstanding as a percentage of the working tanker fleet.
9. X_9 : Index of change in new orders placed.

In this first approach, exponential regression analysis gave better results. Data was divided in two parts, reflecting periods of "high" and "low" market freight rates.

The second study on time charter rates covered the period between 1959 and 1966 [4]. It was similar to the first one apart from the fact that some new variables were included and some old ones excluded. In more detail, the variables used were:

1. X_1 : Ship size in DWT.
2. X_2 : Spot rate of the marginal vessel[3] for the week of the signature of the Time Chartering agreement.
3. X_3 : Duration of the time chartering.
4. X_4 : Lead time between agreement signature and delivery of the ship.

A third model was proposed in [5], and evaluated by S. Polemis [6]. The explanating factors in this work were :

The correcting parameters X_i represent:

- X_1 : the risk premium of underemployment, which we expect to change over time due to technological changes.
- X_2 : The unemployment risk premium, which is a function of time. The longer the duration of the time-charter, the greater the reduction of the risk of unemployment facing the owner of a vessel. We conclude that X_2 will have a minus sign in the additive model and a value of less than one in the multiplicative one. Equivalent risk premium does not exist in the short-term charter market.
- X_3 : Express the brokerage fee savings on the long - term rate. Brokerage fee (usually 1.25% of the total rental involved) is payed by the vessel owner. The final amount paid is proportional to the fee and to the number of brokers involved. With the introduction of large tankers of 100,000 DWT and over and charter agreements extending over 15 - 20 years, often special agreements are made with brokers and the fee may be reduced to as low as 0.75 per cent.

[3] Marginal vessel is the smallest representative vessel in the spot market, serving on a particular route and carrying crude.

- X_4 stands for the mortgageability of the long term charters. The higher the rate and the longer the duration of the charter, the greater the "mortgageability" of the agreement and the owner of the vessel may achieve higher banking financing with lower interest rates.

- X_5 is the efficiency premium of the particular vessel. It takes into account the different operating costs of vessels of different sizes and propulsion. It changes over time, as new technologies are applied. It is actually the projected cost of fuel oil. Obviously, the advantage of an efficient vessel is magnified as cost of fuel increases and vice versa.

The conclusions Zannetos and Polemis reached were:

- The most determinant factor of freight rates is the size of the ship. The two variables are negatively related, reflecting economies of scale.

- Spot rates do not influence long charter rates except in period of crisis. Time Charter rates are defined from the cost of operation of the vessel, and it fluctuates close to break-even rate. Fluctuations, although in the same direction of the spot rates in the time of signature, have smaller amplitude.

- Time Charter rates and duration of charter are negatively correlated.

- There is a tendency of smaller period chartering during period of high spot rates.

- The portion of the world fleet that stays idle is negatively correlated with time-charter and spot rates.

- Also, change of the world fleet that stays idle is negatively correlated with time-charter and spot rates.

- The numbers of orders placed in shipyards for new vessels as well change on the number of orders are positively correlated with time charter rates.

1.3.3 Nersesian

Another methodology of forecasting tanker freight rates was presented in [7]. The method is based on following the movement of the tanker fleet around the world and trying to predict the decisions taken by shipowners at each point in time. It consists of a six layers analysis. In more detail:

The first layer of analysis consists of projecting the total energy demand from the main industrialized and oil-consuming countries (i.e. North America, Western Europe, and Japan, countries of South America as Argentina, Brazil and Chile, South Africa and the Asian countries of India, Pakistan, the Philippines, Korea, Taiwan , Singapore, and Hong Kong). Oil consumption is influenced by noneconomic factors, such as the weather (a heavy winter will cause an increase of oil demand for heating) and government policy such as the pricing of oil [4].

The second layer of analysis consists on predicting the portion of the energy demand that will be covered by each fuel : oil, coal, natural gas, nuclear and hydro. For such a prediction to be accurate, we should consider the policies each country adopts, towards each fuel. For example, countries imposed a ceiling on the imports of crude oil to protect their foreign exchange reserves. Producing countries imposed many times a similar limit on exports to protect their reserves.

In particular, on what concerns the U.S.A. and the consumption of natural gas, the following parameters should be considered:

- the future pricing policies of DOE ,
- the effect of these policies on exploration budgets of oil and gas companies,
- the success of finding new gas fields for any given level for exploration activity, and
- the nature of DOE rulings on liquified natural gas (LNG) imports into the United States.

In the same way, concerning coal we should consider:

- effects of legislation on strip mining

[4]In the early 70s the U.S.A. presented an increased energy consumption rate due to the pricing policy of the U.S.A. government which kept prices of oil and natural gas lower than the international levels.

- mine safety
- pollution standards on the production of coal
- the availability of capital and labor to develop and operate new mines.

Similar studies should cover all the countries that present high levels of energy consumption. This is difficult, as trends sometimes change in an unexpected way. For example, concerning nuclear energy, although it covered 10% - 15% of the total energy demand in the U.S.A., by mid-1980s no serious change occurred since then. This is mainly due to the public attitude towards nuclear stations and the old question of nuclear waste disposal. On the other hand, construction of the natural gas pipeline which will supply Central and Eastern Europe from Russia is scheduled to be completed by 1996.

The third layer of analysis concerns the definition of the portion of the crude oil that will be imported through sea routes. Concerning Japan such a task is easy as it is an inland state, with no domestic production, therefore it must cover all its needs through shipping. Europe and U.S.A. on the other hand, although they are importing crude oil to cover their needs, have their own production as well (Oilfields at the North Sea for Europe, Alaska and Texas for the U.S.A.). The portion of the crude that finally will be imported is defined by the following factors:

- Existence of pipelines that supply crude oil from neighbouring countries. An example is the supply of Western Europe with crude oil from Russia.
- Domestic production, mainly influenced by goverment's policy for exploitation of the domestic oilfields. Concerning the U.S.A., offshore exploration activity is constrained by the timing of lease sales conducted by the Department of Interior and by the public's opposition to drilling off beaches. Domestic production, is also influenced by the oil price policy of governments. For example, in 1979, the U.S.A. government decided to keep the price of domestic oil at $6 while OPEC's oil price in the market was $30 .

Transportation demand is not defined only by the amount of crude oil that should be carried but by the distance between producing and consuming countries as well.

Having defined the quantities needed for import, we have to define the quantities that are going to be exported from each oil-producing country . The exported crude oil may be defined as the oil-production of the country minus its domestic consumption. Projections on the exports of oil-producing countries over a period of time should be made. The main oil-producing countries are Libya, Algeria, Nigeria, Indonesia, Venezuela, the Soviet Union, Mexico and Mainland China and those of the Middle East (Saudi Arabia, Iran, Kuwait, Iraq, Abu Dhabi, Dubai, Qatar and Oman). Finally, having clarified who supplies whom we have completed the **fourth layer of our analysis.**

The fifth layer of our analysis, which estimates the total transportation demand is not a simple calculation (i.e. just the multiplication of cargo by the distance between exporting - importing countries) as for the same port of destination and the same port of call different routes may be used. For example, if a cargo has to be moved from Kirkuk oilfield (Iraq) to Genoa (Italy) the different routes from which we have to choose are:

1. From Kirkuk to Basrah through pipeline and then to Genoa via Cape of Good Hope.
2. From Kirkuk to Basrah through pipeline and then to Genoa via Suez Canal. In this case the pipelines Sumed (connecting the two sides of Suez Canal) or the Trans -Israel pipeline (connecting terminals in Red Sea with terminals in Mediterranean) may be used.
3. From Kirkuk to Dortyol (Turkey) through pipeline and then to Genoa.
4. From Kirkuk to Banias (Syria) through pipeline and then to Genoa .
5. From Kirkuk to Tripoli (Lebanon) through pipeline and then to Genoa.

These routes range from 1,500 n.miles (option 5) to 11,000 n.miles (option 1). Therefore transportation demand is affected by the rate of utilization of pipelines and Suez Canal, which are influenced from the existing spot rates in the market and the tolls for usage of pipelines and Canals. For example, the opening of Suez Canal in 1975 did not influence the spot rates as the tanker market was depressed and for an European importer it would cost more to pay the tolls of Suez Canal than to go around the Cape of Good Hope. Therefore, tolls are influenced from spot rates (and vice versa as the rate of their utilization affects demanded transportation capacity, therefore the freight rates.).

To overcome this difficulty of interdependence between the tolls and future spot rates, we may assume a high rate of utilization of Suez Canal and of pipelines. This is true most of the times, specially when freight rates are high, a period in which shipowners are more interested in predicting future spot rates.

Of course political factors - unpredictable most of the time - may affect the demand of transportation capacity. The closing of Suez Canal in 1967 as well as its reopening in 1975, the shut down of the pipeline supplying Iraqi oil in Haifa, Israel in 1948 from the Iraq Petroleum Company and the IPC pipeline serving Lebanon due to the Libanese civil war in 1982, all were political disputes.

Finally, **the sixth layer of analysis** consists of estimating the future demand for each size of ship. All the ships are not the same. The main difference from the point of view of the charterer is its cargo carrying capacity and its limitations (due to draft) of accessing different ports. Having in mind that an oil importer in Philadelphia (U.S.A.) who wants to import oil from the Persian Gulf, has the following options:

1. Moving the oil with 70,000 dwt tankers (Sumax) through Suez Canal.

2. Moving the oil with 100,000 dwt tankers via the Cape of Good Hope in the laden portion of the trip. When the vessel returns, it may go through Suez Canal. At the port of call, it will deliver some of its cargo to barges before entering the Delaware Bay (due to draft limitations).

3. Using VLCCs or ULCCs via the Cape of Good Hope. When reaching the port, a Single Point Mooring system may be used to unload their cargo. Another option for unloading the cargo will be to use shuttle tankers.

4. Using VLCCs which will be unload their cargo at the Sumed pipeline(running parallel to the Suez Canal). Tankers 70,000 dwt be loaded and they will continue the trip.

5. Finally, another option for unloading the cargo of VLCCs and ULCCs would be the LOOP.

From the above we conclude that, in order to complete this step we should not only look on the various routes the vessel may follow, but other means of crude oil transportation for certain parts of the trip. Economies of scale for VLCCCs and ULCCs should be considered as well as their problems of accessibility in harbors with draft limitations. We always have to be informed about undertaken programs for harbor deepening, as well installation of other loading/unloading facilities such as SPM (Single Point Mooring) or Offshore Oil Pipeline (as the Louisianna L.O.O.P.).

SPMs are installed at ports that present deep sea depth close to shore. Their low installation cost in combination with gains coming from the use of larger vessels, made these facilities the main aspect of port development in the 70s. Their effect was that trade routes that were served from smaller tankers were opened to VLCCs and ULCCs.

Finally another characteristic of the ports that should be considered is the future of the refineries that they supply. U.S.A. refineries are fitted for the treatment of domestic sweet crudes. In the contrary, most European distilleries are fitted for the treatment of the Middle East sour crudes. Therefore we may expect that the sweet crude of the North Sea will be shipped in the U.S.A. to be refined.

Having projected tanker demand for different groups of vessel sizes, the next step will be to project tanker availability. The existing world fleet should be adjusted for new and delayed deliveries, cancellations of orders, losses at sea and scrappage. Scrappage is a function of many factors, the main one being the projected freight rates. Finally, having the projected tanker supply and demand per size category, we may estimate the expected freight rate.

1.4 Mathematical Tool (Regression Analysis).

In many economic, engineering and science problems, where we have to explain or predict a result, the first step would be to determine the effect of different parameters on this single result. Linear regression theory, is a well developed tool for this task and may constitute a first approach to the problem . If one has reason to think that the nature of the problem is non-linear or that assumptions about linearity are violated, further analysis would be needed, i.e. non-linear analysis.

As the variable to be explained in linear regression depends on the value of a set of parameters, it is called dependent variable, and the input parameters $(X_0, X_1, X_2, ..., X_r)$ are called independent or explanatory variables. In many cases, where we can use linear regression, the relation between the dependent variable with the independent ones is linear , i.e. it has the form :

$$Y = \beta_0 + \beta_1 * X_1 + ... + \beta_r * X_r$$

Where $\beta_0, \beta_1, \beta_2, ...$ are constants that have to be determined. Therefore, if we can estimate these coefficients we will be able to know the results for each group of input.

Many times measurements are not very accurate. Therefore what we should expect is

$$Y = \beta_0 + \beta_1 * X_1 + ... + \beta_r * X_r + E$$

where E is the error. The error has a mean equal to zero.

So, the problem is how to estimate the coefficients $\beta_0, \beta_1, ... + \beta_r$ given a sample of n values of each of the variables $Y, X_1, X_2, ..., X_n$ so that will give us the "best estimate". The analysis of the data is called regression analysis, the equation linear regression equation (simple for one independent variable, multiple for more) and the coefficients are called the regression coefficients.

Putting the equations into matrix form, we have the following expression:

$Y = X * \beta + \epsilon$

Where Y is the column vector of the n values of y, β the column vector of unknown coefficients, X the (n,p) matrix which columns show the n-values of an input parameter for the period from where the data was acquired, and by ϵ the column vector of errors.

To have the "best estimate" we have to find the group of coefficients that minimize the error. Assuming that we know the coefficients, the sum of square of errors from each measurement should be minimal. Therefore

$$\Sigma(Y_{meas} - Y_{estim})^2 \qquad \text{minimum.}$$

or :

$$\Sigma(Y_{meas} - \beta_0 - \beta_1 * X_1 - \beta_2 * X_2 - ... - \beta_k * X_k)^2 \qquad \text{minimum}$$

So, to have the least square estimator b of β, we use the following formula, :

$$b = (X' * X)^{-1} * X' * y$$

INDEX OF FIT

The value of

$$R = \frac{\Sigma_{i=1}^{n}(X_i - X) * (Y_i - Y)}{\sqrt{\Sigma_{i=1}^{n}(X_i - X)^2 * \Sigma_{i=1}^{n}(Y_i - Y)^2}}$$

is called coefficient of correlation. In the above formula, X are the values of the single explanatory variable X and mx,my are the sample means of X and Y. The coefficient of correlation takes values from the space between -1 and 1 , and it may be positive or negative, depending on the sample covariation of of the X and Y.

Another useful quantity is the square of the coefficient of correlation which is called coefficient of determination.

For a multiple linear regression, i.e. a regression with more than one explanatory variables, the coefficient of determination (or R-squared) is generally defined as the ratio of the explained sum of squares over the total sum of squares. The total sum of squares is $\Sigma(Y_i - Y)$, which is a measure of the total sample variation of the dependent variable. Recall that we are estimating y by Xb, where b are the least-squares estimate of β. Therefore, the part of the total variation which is explained by the regression (i.e. the explained sum of squares) is given by the same formula as the total sum of squares but with the i-th component of Xb in the place of Y. A perfect linear regression would explain all the sample variation of the dependent variable, resulting in a coefficient of determination equal to 1. Generally, R-squared takes values between zero and one, and it expresses the percentage of the total variation in Y explained by the regression model. The coefficient of determination is a useful tool for comparing regression models, but it has a major shortcoming: it is a non-decreasing function of the number of explanatory variables presented in the model. This means that , if we add any variable to a model, the coefficient of determination almost invariably increases and never decreases. In view of this, R-squared is inappropriate for comparing regression models with the same dependent variable but different numbers of explanatory variables. In order to deal with this difficulty, one defines the adjusted R-squared, R2 , in the following way:

$$R^2_{adj} = 1 - (1 - R^2) * \frac{N-1}{N-p}$$

The adjusted R-squared is appropriate for comparing regression models with different numbers of explanatory variables. In contrast with R-squared, the adjusted R-squared can be negative, in which case it is considered to be zero.

Chapter 2

Model Development

2.1 Introduction.

The purpose of this model is to forecast **spot rates** in the crude oil market. Spot freight rates will be assumed as an expression of the **idle portion of the fleet**, as well as of the size of the ship.

As mentioned, freight rates for the same time moment and for the same route differ according to the size of the ship [1]. Therefore the tanker fleet is going to be divided in four groups, based on the ship sizes. Each size group shows a different relation between inactivity and freight rates. The four groups are:

1. Small vessels (40,000 - 70,000 DWT)
2. Medium size vessels (70,000 - 100,000 DWT)
3. Capesize size vessels (100,000 - 160,000 DWT)
4. Large size vessels (200,000 - 300,000 DWT)

The idle portion of the fleet may be defined - for each size group - as the ratio of the idle fleet capacity (available minus demanded) over the available capacity.

In our investigation, we will attempt to express the **demanded transportation capacity** as a function of the industrial production of the heavy industrialized countries. Apart from industrial demand for oil, household consumption (heating, transportation) is

[1] There are other factors that make freight rates differ. These are going to be discussed later.

considered. If this is the case, it will show a dependence on the welfare of people which may be expressed as the Gross Domestic Product (per capita) of the country. Therefore, GDP will be tested as an explanatory variable .

Future ship availability may be estimated on the basis of the erosion of the existing tanker fleet through scrappage, and the addition of newbuildings currently on order .

Issues such as employment of the combined cargo fleet in dry cargo trades, hidden inactivity (slow steaming) or inactivity for other reasons (maintenances/inspections, repairs - dry docking,deadfreight, excess port time) have not been considered.

Idleness in our investigation includes all tankers which have not moved for two months or more and all tankers reported to be laid up. Scrappage rate will be given as a function of today's market condition and the portion of the fleet which is "old" . The critical age after which a ship is considered "old" will also be investigated.

Finally, freight rates will be defined as an expression of the estimated portion of the fleet (per group of tanker size) in idleness.

In our model, the spot market will be assumed as ideal, perfectly competitive. The reasons that drive us to this conclusion are the following:

- New competitors may enter the market whenever they wish. No restrictions exist.

- The large number of the owners that decline to join or form a consortium. Although some attempts have been made either towards a common policy or control of the market by individuals, the shipowners remain strongly competitive against each other. The most serious attempt for dominance over the tanker market has been made in 1973 by shipowner Ar.Onnassis . Although he managed to control a large portion of the world tanker fleet at one moment, he had to abandon his plans under the pressure of the boycott the large oil companies exercised on his vessels.

- Large oil companies own only a small portion of the world tanker fleet, therefore they can not affect freights. On the contrary, they take part in competing, acting as individuals, chartering to competing oil companies their tankers if they are idle .

- In industry, the state may "protect" it from foreign competition or burden it with heavy taxation, thus producing "inefficiencies" in the perfect market concept. This is not true for the shipping market, ships are able to change flag at any time. Shipowners have to comply with regulations only when these are adopted by international institutions [2]. Ttherefore the concept of the perfect competition still holds.

- New shipowners have no restrictions to affront whenever they wish to enter the tanker market. For a newcomer, financing is available to him as well[3]. Also, although economies of size exist, some routes are not available to large vessels due to navigational restrictions (limited draft ports). Finally, a large administrative structure is not necessary as in each port independent brokers are available to supply the ship with fuel, water , food, and engine spare parts, if needed.

Also, another assumption is that demand for tankers is not affected by ship's freights. This may be justified by the following:

- The cost of oil transportation is a minor portion of the total production cost of oil and its products.

- Oil industries cannot change to other fuels easily nor they can reduce their outputs. Therefore their needs are price inelastic. In the long run, if high oil prices persist, the factories will move to other sources of energy, reducing the demand in oil. From history, persisting high oil prices were never a result of excess transportation demand (and high tanker freights), but was a result of oil-producing countries[4] policy.

- In a large extent, no substitution of the ocean transportation exists. Of course, the cargo owner may prefer to use oil pipelines and/or Suez-Panama Canal to shorten the length of the voyage in periods where high rates prevail in the tanker market. But we have to keep in mind that tolls of Canals crossing and payments for use of oil pipelines fluctuate in parallel with tanker freights.

[2]Exception to this is ships under "Jones Act" and the drive of double-hull concept the U.S.A. imposed on the new orders.

[3]Financing as high as 80% have been reported in periods of high tanker rates. After a period of 6 - 7 years, when the loan will have been repaid, shipowner may expect a satisfactory return on his investment.

[4]Therefore, against the common perception, persisting high oil prices is not on the interest of oil-producing countries as part of the industry will move to other energy sources. The portion of the market lost is very difficult - if not impossible - to be regained.

2.2 Tanker Demand.

2.2.1 Qualitative Analysis.

The need for oil transportation is a function of the industrialized countries' oil consumption, the regional availability of oil (reserves, policy of country and price, oil-pumping capability), and the development of new transportation systems (mainly pipelines - oil and natural gas).

Oil consumption is proportional to the industrial production of each country. Other energy sources may be used (nuclear, solar, aeolic, hydraulic,natural gas) and that was the trend after the oil crisis of 1973 - 74. But soon after they were abandoned due to the lack of natural resources in sufficient level (hydraulic,solar), waste treatment problems and high associated risks (nuclear) and energy storage problems (aeolic). Although the feasibility of the above means to explore natural resources existing, the related costs (per kWh of energy produced) are much higher than if oil-driven power stations were used.

Finally, natural gas was found in small quantities far from the main consuming areas. At this moment, due to political instability and internal conflicts, Algeria, the main supplier of natural gas in Europe has almost stopped providing it. Also, due to the confrontation of the two super-powers, the natural gas pipeline that would supply Western Europe from the Russian reserves was not materialized. In the early 90's, when political disputes eased, the construction of the pipeline began and is expected to be completed by the end of 1996. However, no large amounts of natural gas are used as an alternative fuel for power stations.

As oil remains the main driving power behind power stations, it is expected that the industrial production of Japan, U.S.A. and Western Europe affect the tanker's demand for oil transportation. It should be noted that:

- Japan heavily depends to oil imports. There is no domestic production as in mainland U.S.A. (Texas), or Europe (North Sea oilfields)

- Japan is an island state and all its oil imports should be made through sea routes (no pipelines),

- Finally Japan is farther away from all main oil producing areas (Indonesia, Middle East) than U.S.A. (Gulf of Mexico, Alaska) and Europe (Azerbaitzan,Libya, Coast of Ivory, Middle East). An exception is the oil producing area of Alaska. It should be noted that it would be in the interest of both countries - Japan as well as U.S.A. - if Japan imported oil from Alaska. At the same time, U.S.A. would import more oil from the Carribean (and less from Alaska) thus not having to send tankers from Alaska all the way around through Panama Canal (or even Maggelan Straits for larger tankers) to supply the United States East Side.

We conclude that all countries do not affect demand for oil transportation through sea ways proportionally to their industrial production. Japan affects to a greater extent the demanded capacity than the other industrialized countries.

Another factor that we should look at is how each size group is affected by a change in the industrial production of a country. Japan with its deep ports and extended unloading facilities is expected to affect the larger size groups.

Smaller size groups should be affected by oil demand of countries that do not have deep ports. There are few ports in the world in which a ULCC may come in fully loaded. The usual procedure is that a ULCC will unload part or all of its cargo to smaller tankers when it reaches the vicinity of the arrival port. Therefore, as all countries use smaller tankers it is expected that demand for small size tankers will be proportional to the oil needs of the country (and consequently with its industrial production).

During the last ten years another change occurred in the tanker market. Main oil trade routes do not connect anymore just oil producing to consuming areas. Discharging zones must be regarded as well as countries with large oil refining capacity such as those in Southeast Asia.

2.2.2 Quantitative Analysis.

In the following analysis the relation between the demand for each of the four main size tanker groups and the industrial production of the most industrialized countries is investigated. The Industrial Productions of U.S.A., Japan and O.E.C.D. were used as explanatory variables.

One might expect that the consumption of oil from households also affects the need for oil transportation. Also it may be assumed that the household oil consumption is proportional to the country's Gross Domestic Product (actually to the Gross Domestic

Product per capita). Gross Domestic Product includes industrial production, agriculture and services[5]. So, the G.D.P. of U.S.A. , Japan and of two typical Europen countries - United Kingdom and France - were investigated as explanatory variables.

For medium size tankers (70,00 - 100,000 DWT) and for large size ones (200,000 - 300,000 DWT), the data included in our analysis covers a period of 120 months : from Jan 1983 to Dec. 1992. For small size tankers (size of ships : 40,000 - 70,000 DWT) and for capesize ones (100,000 - 160,000 DWT) the data covers a period of 52 months (Jan 85 - Jul. 90).

As far as it concerns the latter two size groups (size of ships : 40,000 - 70,000 DWT and 100,000 - 160,000 DWT) the reason for using less data was the following : although from a mathematical point of view a high degree of explanatory power was achieved (R_{adj}=0.7194) it gave poor results in the validation test (comparison between the actual demand and the forecasted one for the period Jan. 1993 - Dec.1993). An explanation to this discrepancy, may be that data taken when market was in recession (Jan 1983 - Dec. 1985) as well as data corresponding to a high unstable market due to uncertainty (Kuwait War :Aug 1990. till the and of our data series.) should be excluded . The period of recession is clearly shown in Fig. 1, where the drop of total available capacity while demanded capacity remains constant may be clearly seen. After this assumption had been taken into consideration and the data from the above time intervals was excluded, the resulted formula was validated achieving both a high degree of explanatory power for past results and a good agreement between forecasted and future[6] demand.

In more detail the results were the following :

1. Size Group : 40,000 - 70,000 DWT

   $D_1 = 155.2477 - 2.3049 * X + (1.1616/117.22) * X^2$

   $R^2_{\text{adj}} = 0.8180$

   Where:

   D_1 : Demand for oil transportation [million DWT]

   X : Industrial Production of O.E.C.D. [100 : 1980]

   As it was expected for small tankers, the industrial production of all the industrial-

[5]For the U.S.A. the structure of G.D.P. is 10% agriculture, 20% industrial production and 70% services.
[6]"Future" in comparison to our data bank

ized countries affected their demand.

2. Size Group 70,000 - 100,000

$D_2 = 134.0227 + 0.4117 * Y - 2.2628 * Z + (1.1616/130.902) * Z^2$

$R^2_{\text{adj}} = 0.8366$

Where :

D_2 : Demand for oil transportation [million DWT]

Y : Industrial Production of U.S.A. [100 : 1980]

Z : Industrial Production of Japan [100 :1980]

Note : A fluctuation in the Industrial Production of the U.S.A. and Japan will be reflected to the market (proportional fluctuation in tanker's demand) two months afterwards.

3. Size Group 100,000 - 160,000 DWT

$D_3 = 240.9027 - 1.9133*Y + (0.9099/120.9487)*Y^2 - 1.6234*Z + (0.8433/130.902)*Z^2$

$R^2_{\text{adj}} = 0.6971$

D_3 : Demand for oil transportation [million DWT]

Y : Industrial Production of U.S.A. [100 : 1980]

Z : Industrial Production of Japan [100 : 1980]

Note : A fluctuation in the Industrial Production of the U.S.A. and Japan will be reflected to the market (proportional fluctuation in the tanker's demand) one month afterwards.

4. Size Group 200,000 - 300,000 DWT

$D_4 = 3964 + 0.4354 * Y^3 - 10.6691 * Z + (5.1504/130.902) * Z^2$

$R^2_{\text{adj}} = 0.7838$

D_4 : Demand for oil transportation [million DWT]

Y : Industrial Production of U.S.A. [100 : 1980]

Z : Industrial Production of Japan [100 : 1980]

No correlation was found between the G.D.P. of U.S.A., Japan France and United Kingdom and the demanded oil transportation capacity, when industrial production was also used as an explanatory parameter. This merely shows that there is no relation between G.D.P. and tanker demand. On the contrary, it invokes the high degree of correlation between Industrial Production and G.D.P.

After having analyzed the demanded capacity in an explanatory point of view, a validation test was conducted - as it was mentioned above - comparing the data predicted by our model with the actual ones. Figures 2.3,2.4,2.5 and 2.6 show the good agreement between the results from our model and the actual values for each size group.

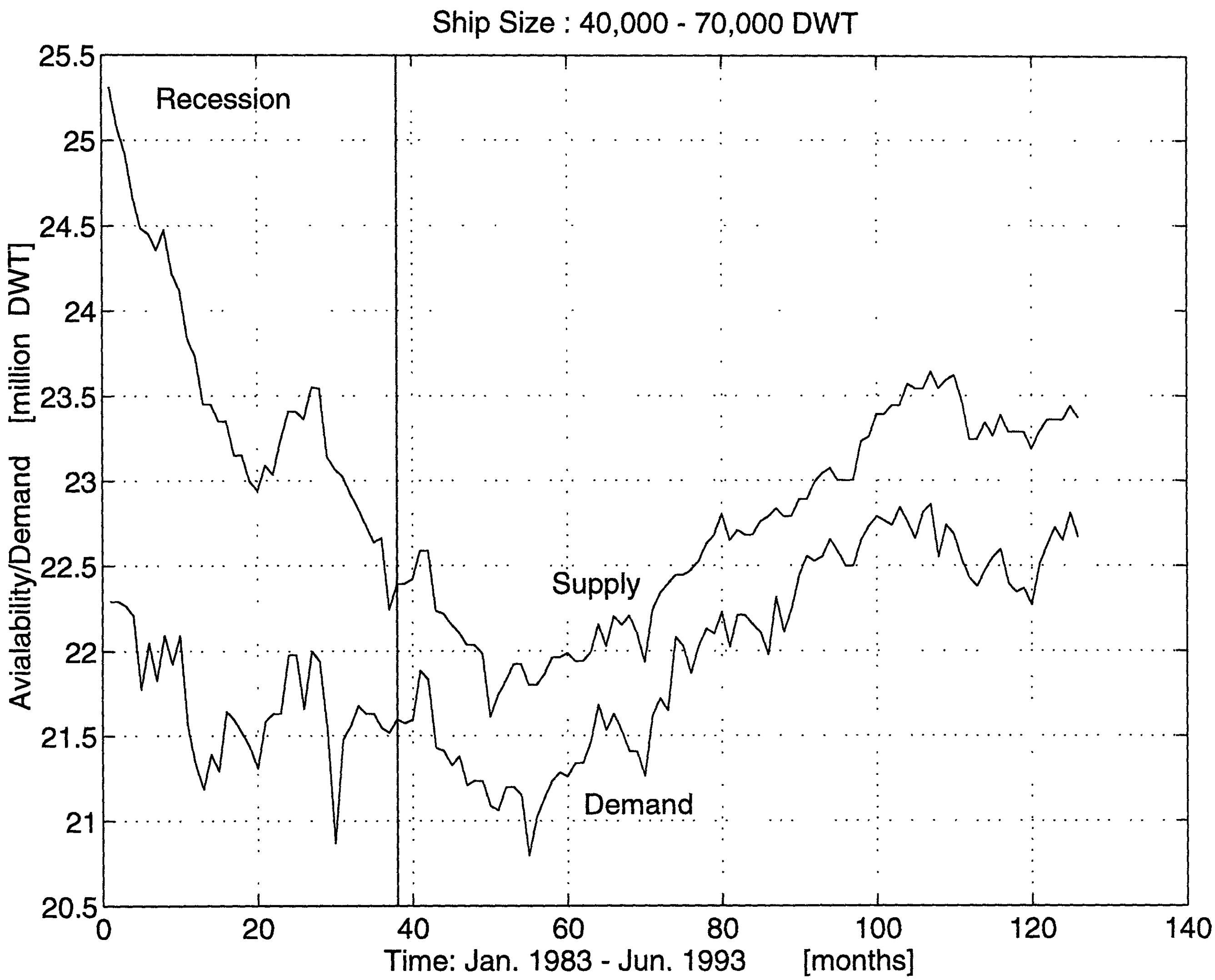


Figure 2-1: Defining Recession Period

2.2.3 Conclusions.

From the above analysis the following conclusions were reached:

- The demand for small size ships (40,000 - 70,000 DWT) is proportional to the industrial production of the O.E.C.D.

- The demand for medium ship sizes (70,000 - 100,000 DWT), are proportional to the Industrial Production of U.S.A and Japan. It was also noticed that an increase in industrial production of the above two countries will be reflected to tanker's market two months afterwards.

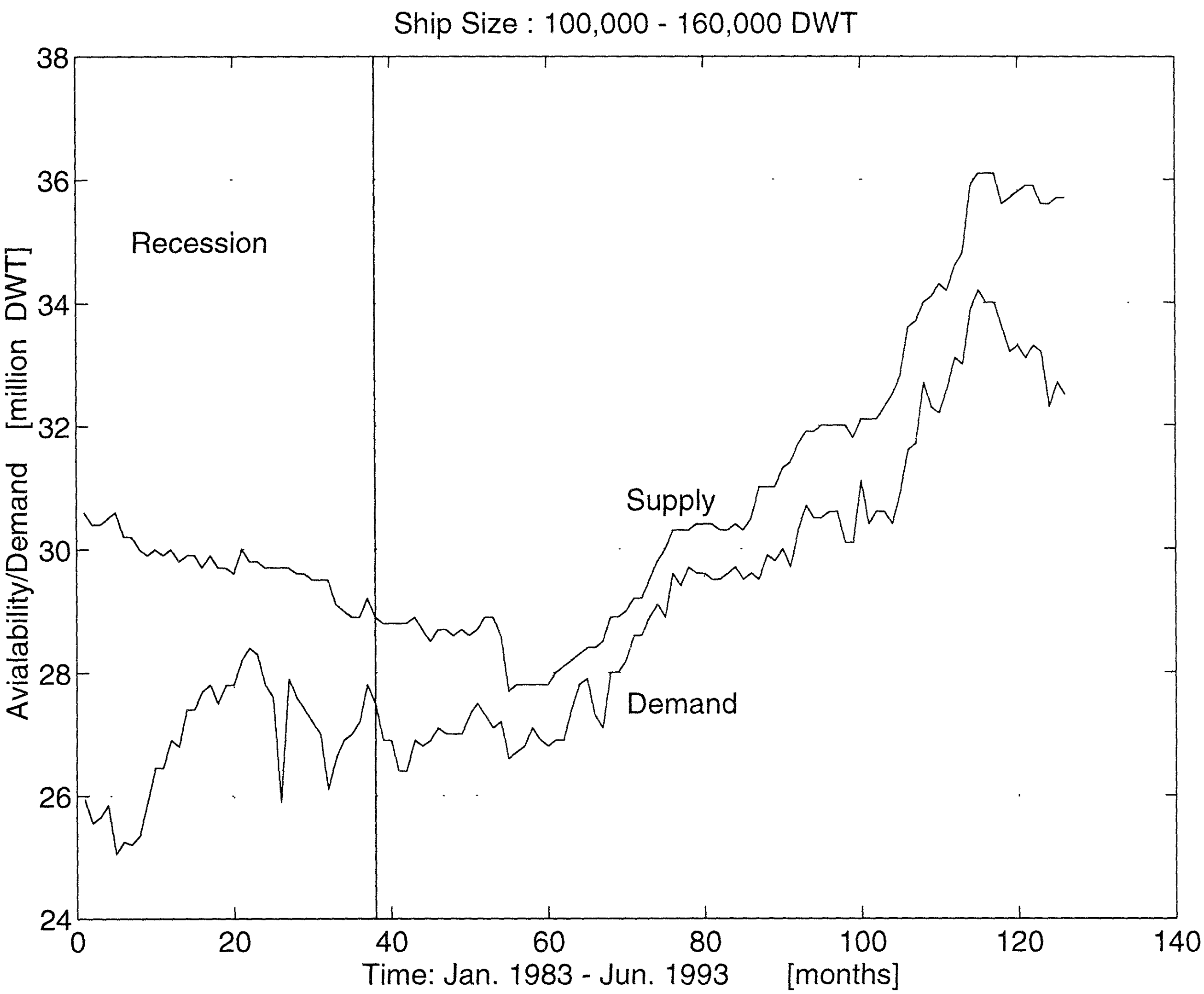


Figure 2-2: Defining recession Period

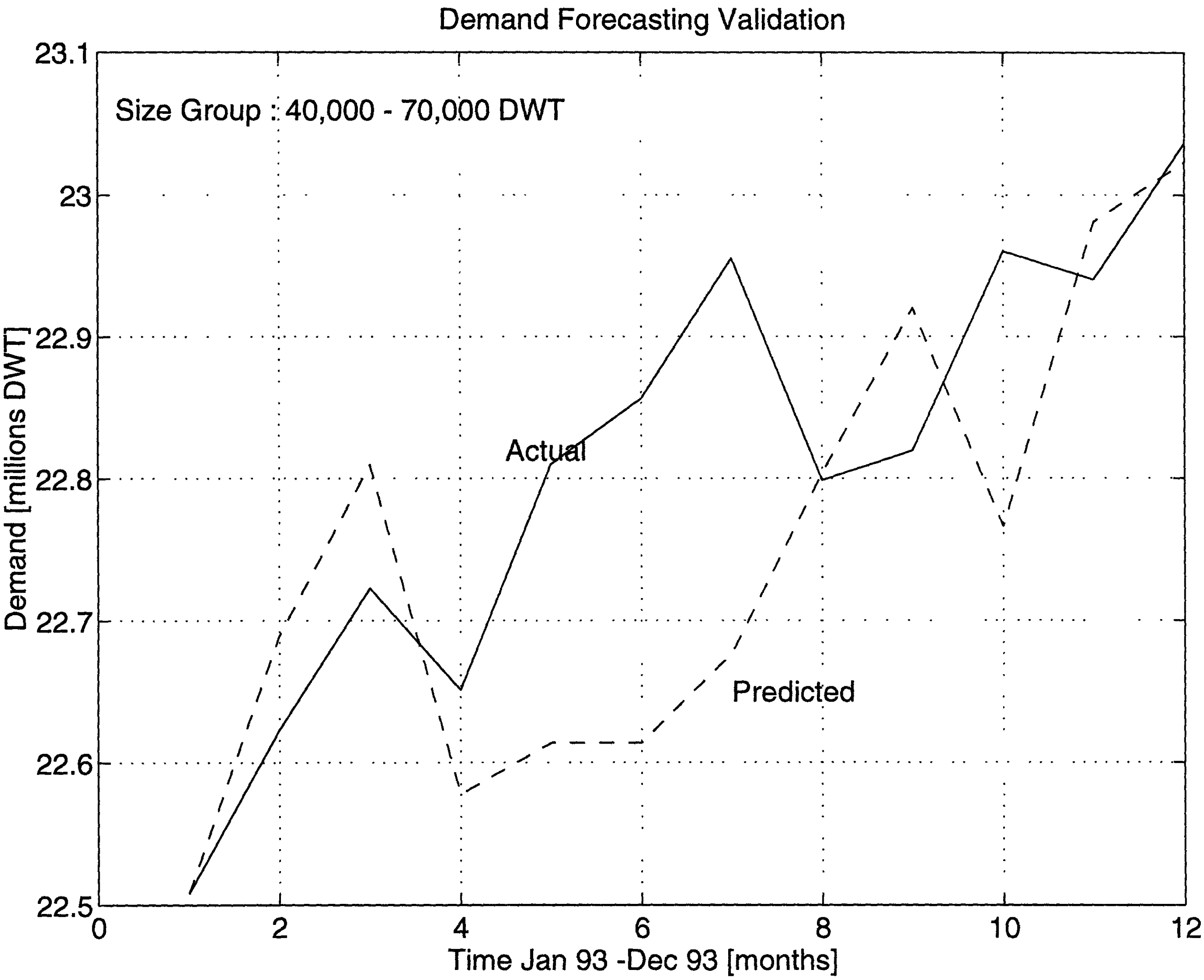


Figure 2-3: Demand Forecasting Validation

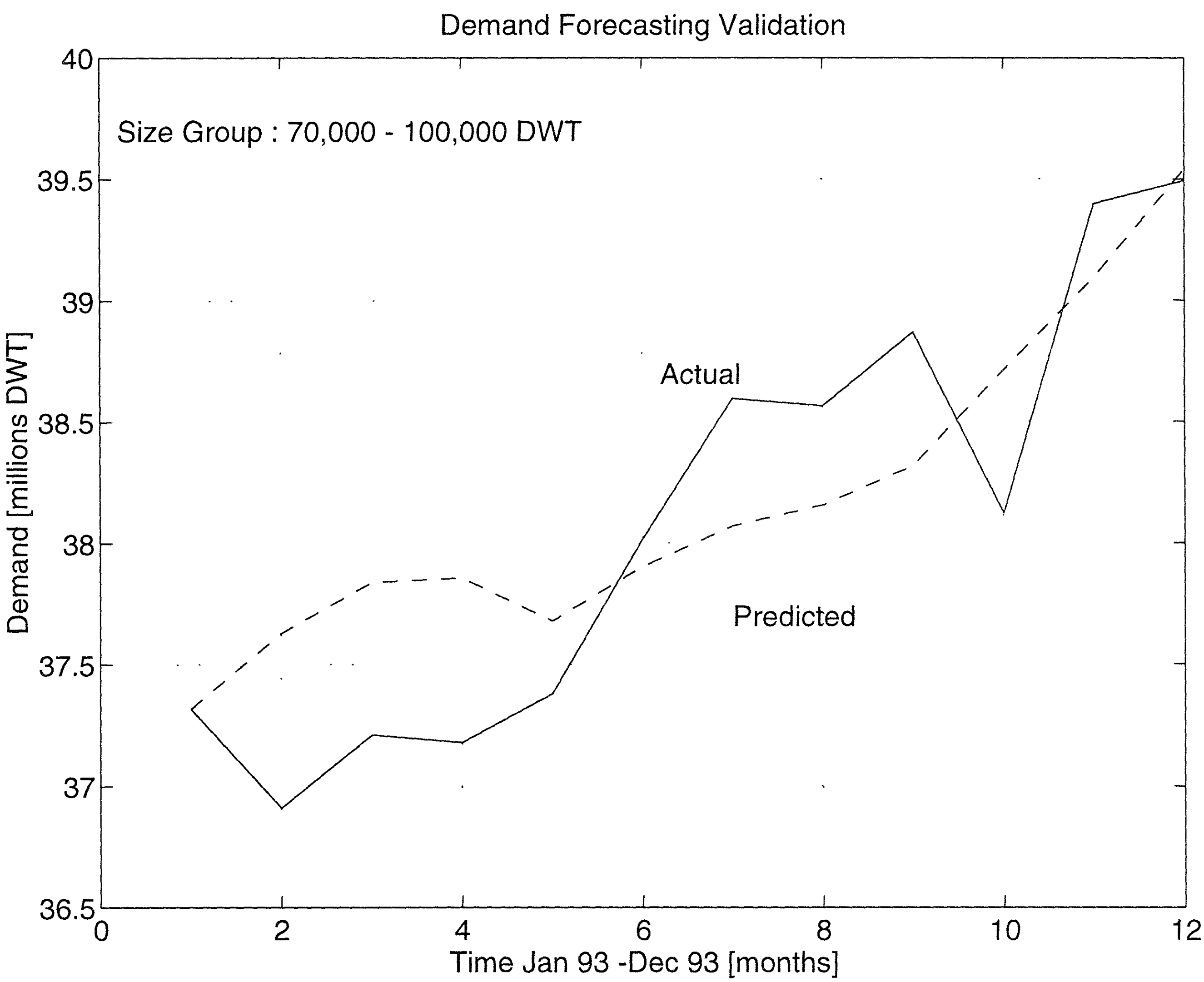


Figure 2-4: Demand Forecasting Validation

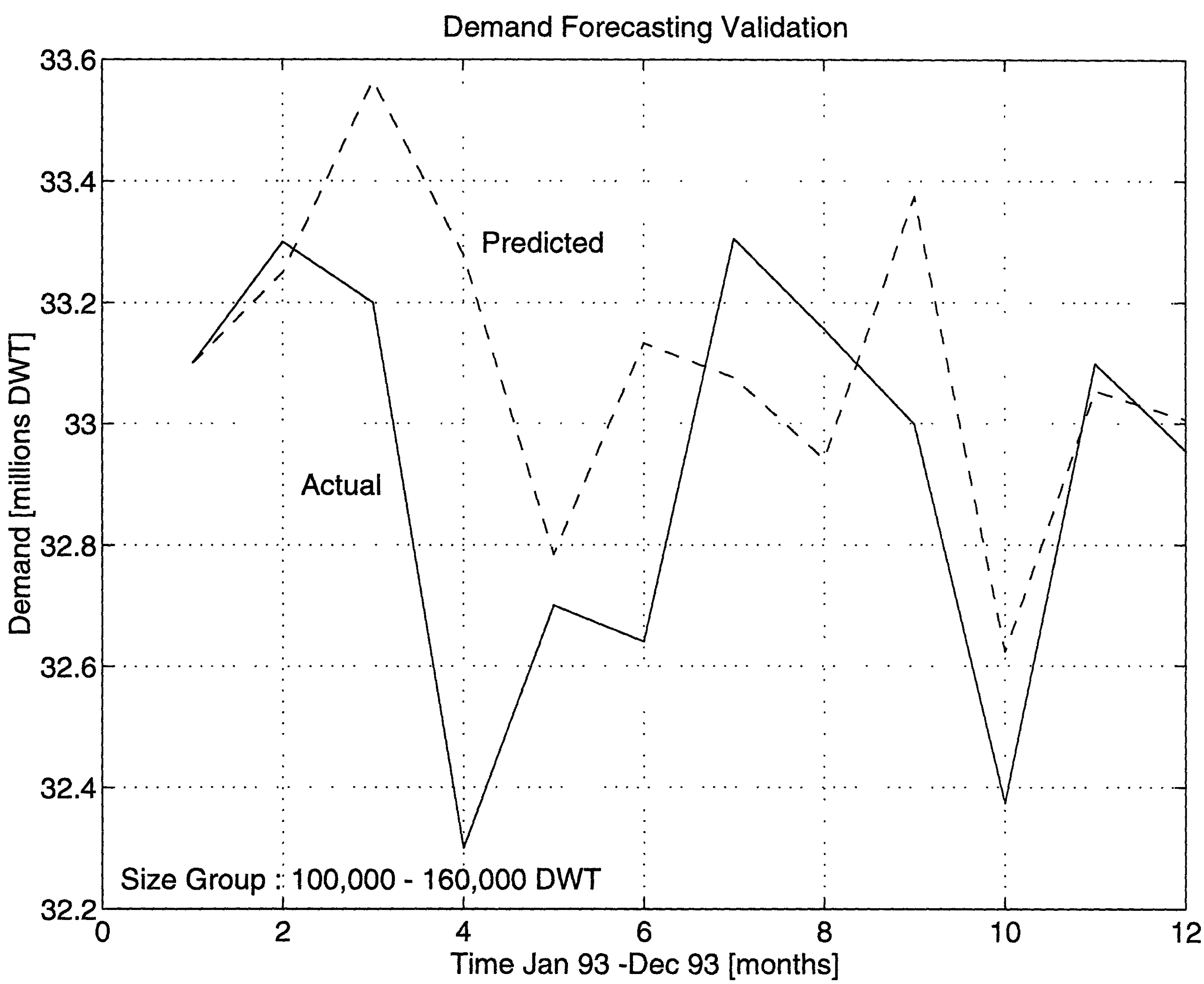


Figure 2-5: Demand Forecasting Validation

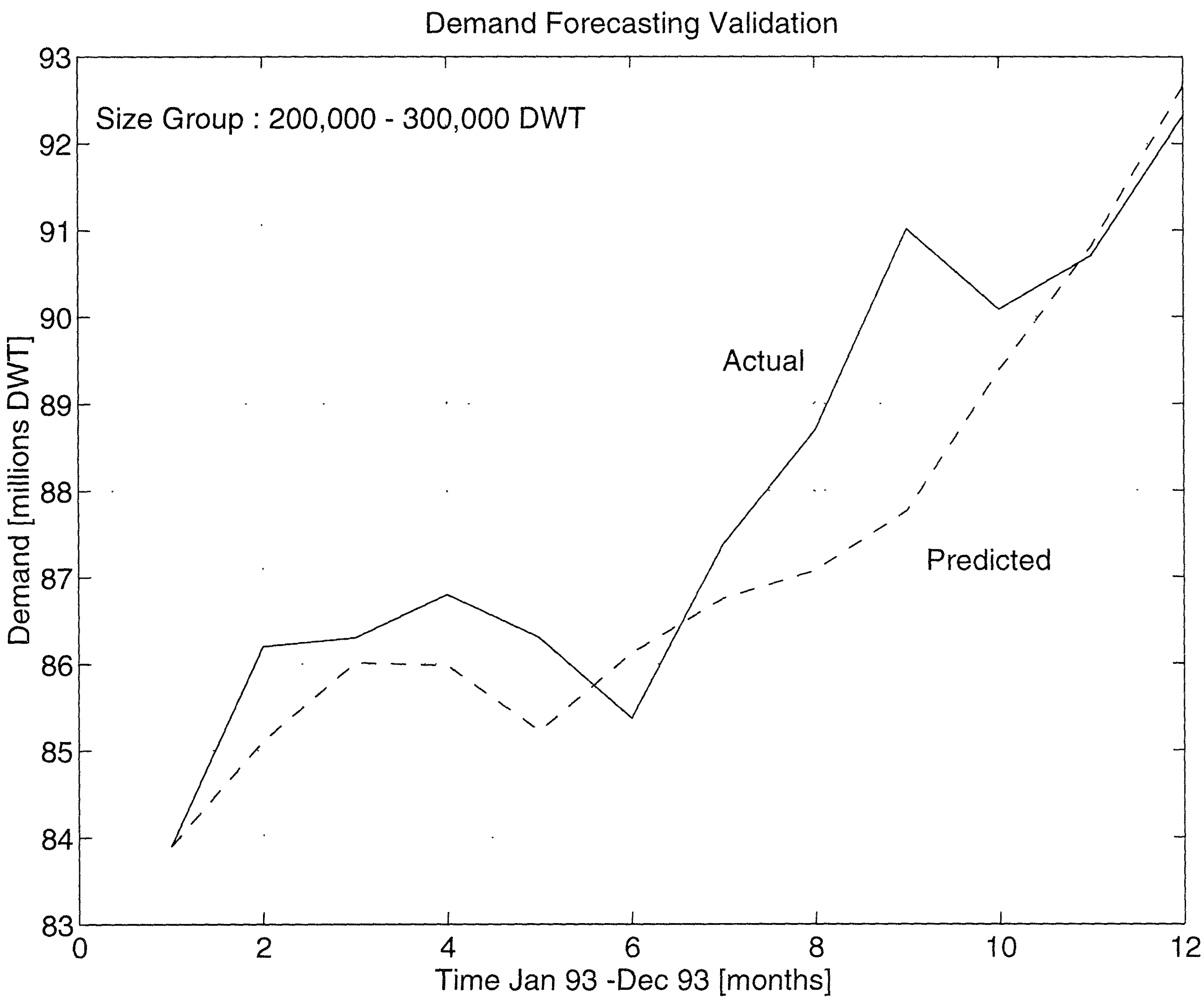


Figure 2-6: Demand Forecasting Validation

- Demand for Capesize tankers (100,000 -160,000 DWT) is influenced by the Industrial Production of the U.S.A. and - to a smaller extent - by the Industrial Production of Japan. A fluctuation in Industrial Production of these two countries will be reflected to tanker's market one month afterwards.

- Demand for large tankers (200,00 - 300,000 DWT) is proportional to the Industrial Production of both the U.S.A. and Japan.

- The formulas derived cannot describe the demand for small size tankers (40,000 -70,000 DWT) and medium size tankers (100,000 - 160,000) during periods of recession or periods with high uncertainty (wars,political instabilities) on the future oil prices.

- Formulas that predict demand for medium (70,000 -100,00 DWT) and large size vessels (200,000 -300,000 DWT) are valid for all market conditions : market in recession, market in equilibrium or market characterized by excessive demand due to uncertainty for future prices.

- G.D.P. offers no more explanatory power than the industrial production, as these two parameters are highly dependent between on other.

- There is good agreement both in explaining and in predicting analysis of the demanded capacity as a function of the industrial production of the most industrialized countries in the world.

2.3 Tanker Availability.

2.3.1 Qualitative Analysis.

By the term tanker availability we refer to the total capacity that may serve on the transportation of crude oil. The simplistic approach that tanker availability is equal to the total fleet capacity is going to be assumed. The total fleet capacity does not correspond to the available capacity exactly. Ships dry-docking for surveys and repairs should not be included in the available capacity. Also, as we refer to spot rates of crude oil cargo ships, we should exclude ships that are used to transport "clean" cargo (i.e. refined oil products) as well as ships that are long-term chartered. Finally we should include combined cargo vessels (Ore/Bulk/Oil) that they may be operate in the oil market or in the dry bulk market, depending on the rates of the two markets.

It should be noted that it is a rare phenomenon to see a shipowner to transfer a specialized ship ("combined" cargo or "clean" cargo) from the dry bulk market or from "clean" oil market to the crude oil market, as this invokes an additional expense to the him (cleaning of the store areas, "idle" time to transfer the vessel from one region to another). Also, considering the small amount of capacity that is out of market dry-docking we may assume that it may be neglected.

Another argument supporting the hypothesis that we may omit dry-docked capacity is the following. When freight rates are low, shipowners are not reluctant to finish any repairs thus we may see the dry-docking capacity increasing. Also, when freight rates are low, the idle capacity of the fleet increases. Therefore dry-docking capacity is dependent on the freight rates. As in our model freight rates will be expressed as a function of the idle portion of the fleet[7], we are justified not to use the dry-docked capacity as a separate variable for calculating the available capacity of the fleet (and from there the idle capacity) , as both variables (available and dry-docked) are dependent on the prevailing tanker rates of the market.

Feature available capacity may be found by adding newbuildings and subtracting ships that went for scrap.

As it takes two years on average for a ship to be build, newbuildings may be assumed

[7] The idle portion of the fleet is the ratio of the idle capacity (available minus demanded) over the available capacity.

known for a period of two years.

Predicting the capacity of scrapped ships is much more complex. As ship's age increases the same happens with its operation costs (in comparison with newbuildings that use more automated systems, and more fuel-efficient engines), its insurance cost and its repair and maintenance costs. There is not a critical age for ships after which they may considered "old" after which possibilities for scraping rise enormously. In general, few ships will be scrapped before the age of ten years. Thereafter the rate will accelerate with age, and the critical period is often at special survey times (every 4/5 years - with extension may be reach 6) when the cost of maintaining a ship to classification society standards is often prohibitive in view of its remaining trading life.

Other reasons that may affect the scrap rate of ships are:

1. Regulations: The ratified IMO safety and anti-pollution regulations and the ships standards mandated by certain nations (e.g. the United States Port and tanker Safety Act) require vessels carrying oil to have certain equipment on board such as Inert Gas Systems (IGS), Crude Oil Washing (COW) and Segregated or Dedicated Clean Ballast Tanks (SBT/CBT). Ships without equipment are liable to suffer a high rate of scrappage.

2. Market Conditions: Historical evidence indicates that rates of scrappage are high when tanker freight rates are low. Conversely when the freight market is buoyant, scrappage diminishes.

3. Scrap prices: High scrap prices can at times attract more ships to the breakers' yards. Ship scrap prices are to a certain extent, however, governed by prices for other forms of ferrous waste and by the value of the end product, i.e. melting scrap, or re-rolled material. In general, fluctuations in vessel scrap prices will have a minor influence on the amount of tonnage sold for breaking.

Also it should be noted that due to their poor economic performance, steam turbine ships will tend to suffer a higher rate of scrapping than marine diesel units.

2.3.2 Quantitative Analysis.

In the following analysis the relation between the market conditions (high or low freight rates) and the tonnage leaving the market for scrap is going to be investigated. Also the relation - if any - between the "aged fleet" and the scrapped capacity is going to be determined.

The following procedure was used: For every size group the relation between the freights and the scrapped tonnage was found (see figures 2.7,2.8,2.9 and 2.10 for scrap rate). Also the "age" over which a ship may be considered old was assumed and different values of this age were investigated for all the four size groups. The aged capacity had to be calculated for each month and for each size group each time the "threshold" age was changed (see Figures 2.11 and 2.12 for the age profile of two Ship Size Groups : 70,000 - 100,000 and 100,000 - 160,000 dwt, for the period Jan. 1983 - Dec 1992).

Size Group 40,000 - 70,000 dwt:

$S_1 = 1.4120 * 10^{-2} - 17.83 * *10^{-5} * WS_1 + 56.2987 * 10^{-7} WS_1^2$

$R_{adj} = 0.6980$

Considering the "aged" fleet did not give a better fit.

Size group 70,000 - 100,000 dwt:

Considering the "aged" fleet, the following results were derived: age: 17

$S_2 = 7.2166 * 10^{-2} - 1.5024 * WS_2 * 10^{-4} + 64.5 * WS_2^2 * 10^{-7} + 0.6372 * OC_2 * 10^{-8}$

$R_{adj} = 0.6973$

Where "oc" is the capacity of this size group if we consider only ships 17 years old or older. Different ages were investigated but they showed worse results.

If we do not consider the "aged" fleet, the results are the following:

$S_2 = 8.0627 * 10^{-2} - 1.2760 * WS_2 * 10^{-4} + 53.4433 * WS_2^2 * 10^{-8}$

$R_{adj} = 0.6436$

As we can see the explanatory power of the "aged" capacity is small.

Size Group : 100,000 - 160,000 dwt:

No correlation was found between the scrapped capacity of this size group and the freight rates. On the contrary, if "aged" fleet is considered the capacity of this size group of ships that are 13 years old and older, the following result is achieved:

$S_3 = 2.8251 - 5.3743 * WS_3 * 10^{-5} + 1.4512 * OC_3 * 10^{-8}$

$R_{adj} = 0.4528$

The above results should be used with great care because of the low degree of correlation and because of the period from where the associated data were derived. The early and mid-80's where characterized by a surplus in this tonnage built-up in 1974-76 and many ships went for scrap although they were regarded as new.

Size Group 200,000- 300,000 dwt:

For this size group both freight rates and "aged" capacity affect the scrapping rate. It was found that we have to consider ships 14 years old and older in our analysis. The following numerical results were achieved:

$S_4 = 8.1709 * 10^{-3} - 2.9727 * WS_4 * 10^{-5} - 0.6034 * OC_4 * 10^{-8}$

$R_{adj} = 0.6636$

Omiting the "aged" fleet as an explanatory variable, the following results were derived;

$S_4 = 15.1690 * 10^{-3} - 45.7189 * WS_4 * 10^{-5} + 352.9177 * WS_4^2 * 10^{-8}$

$R_{adj} = 0.5072$

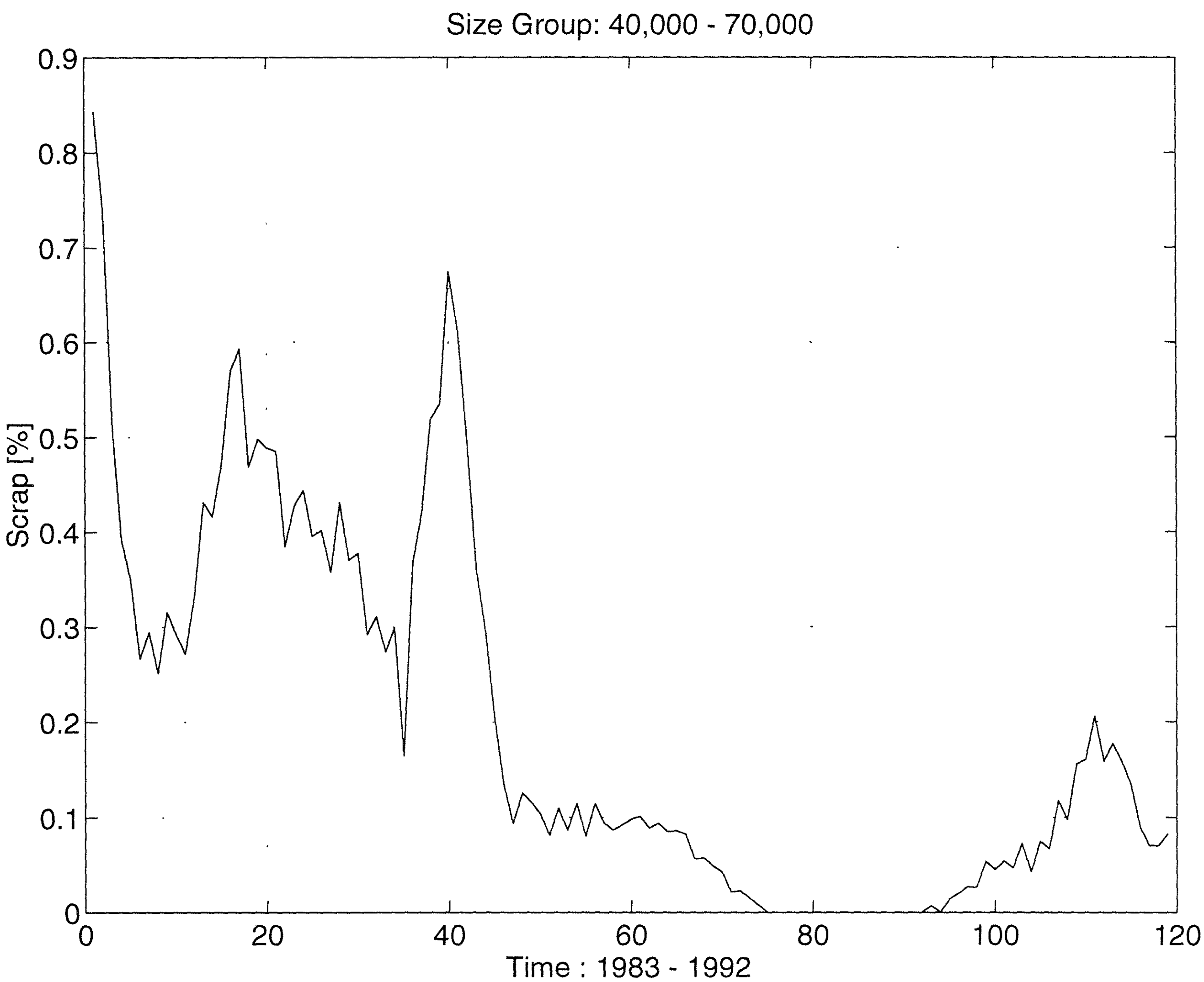


Figure 2-7: Percentage of Size Group Capacity Scrapped

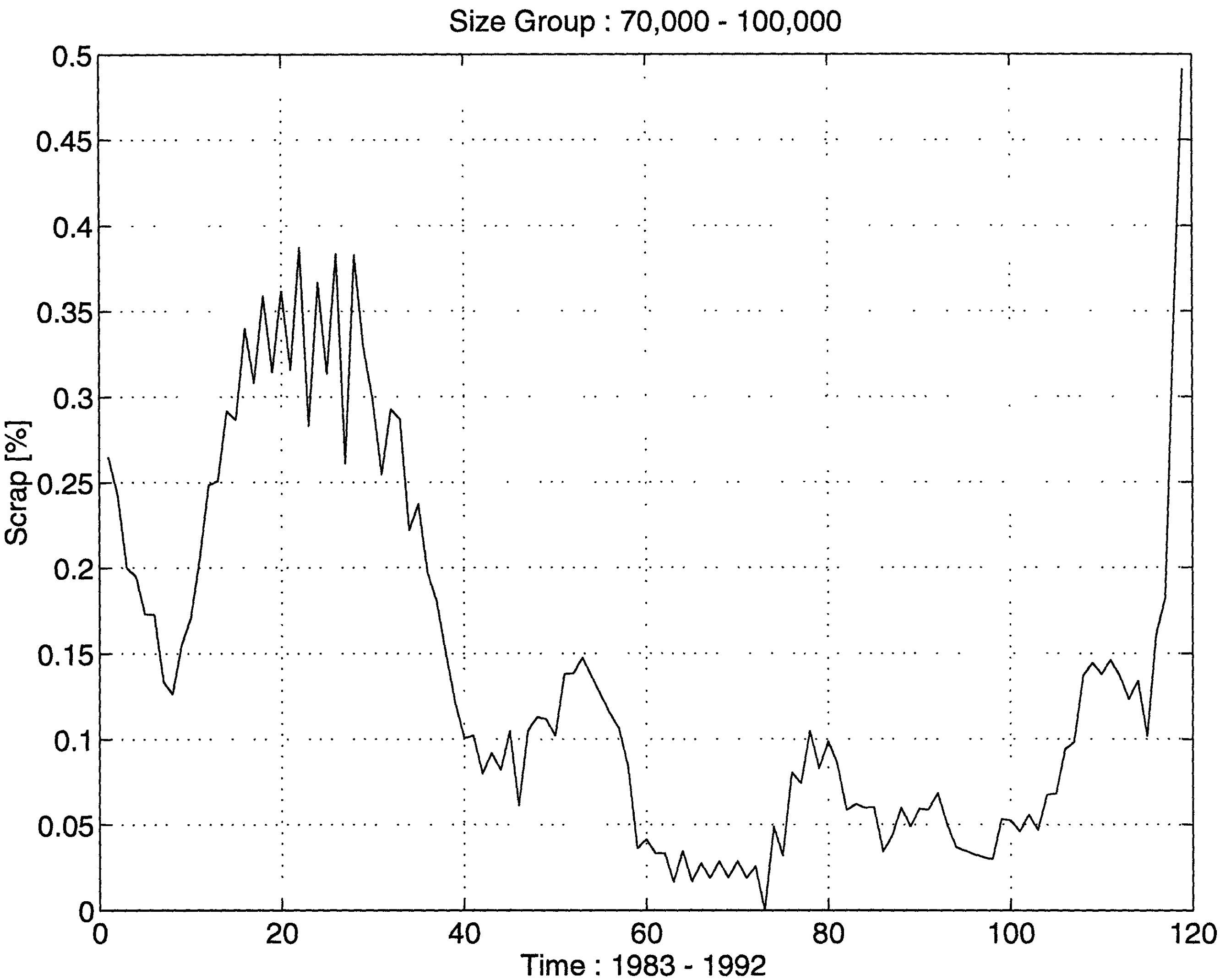


Figure 2-8: Percentage of Size Group Capacity Scrapped

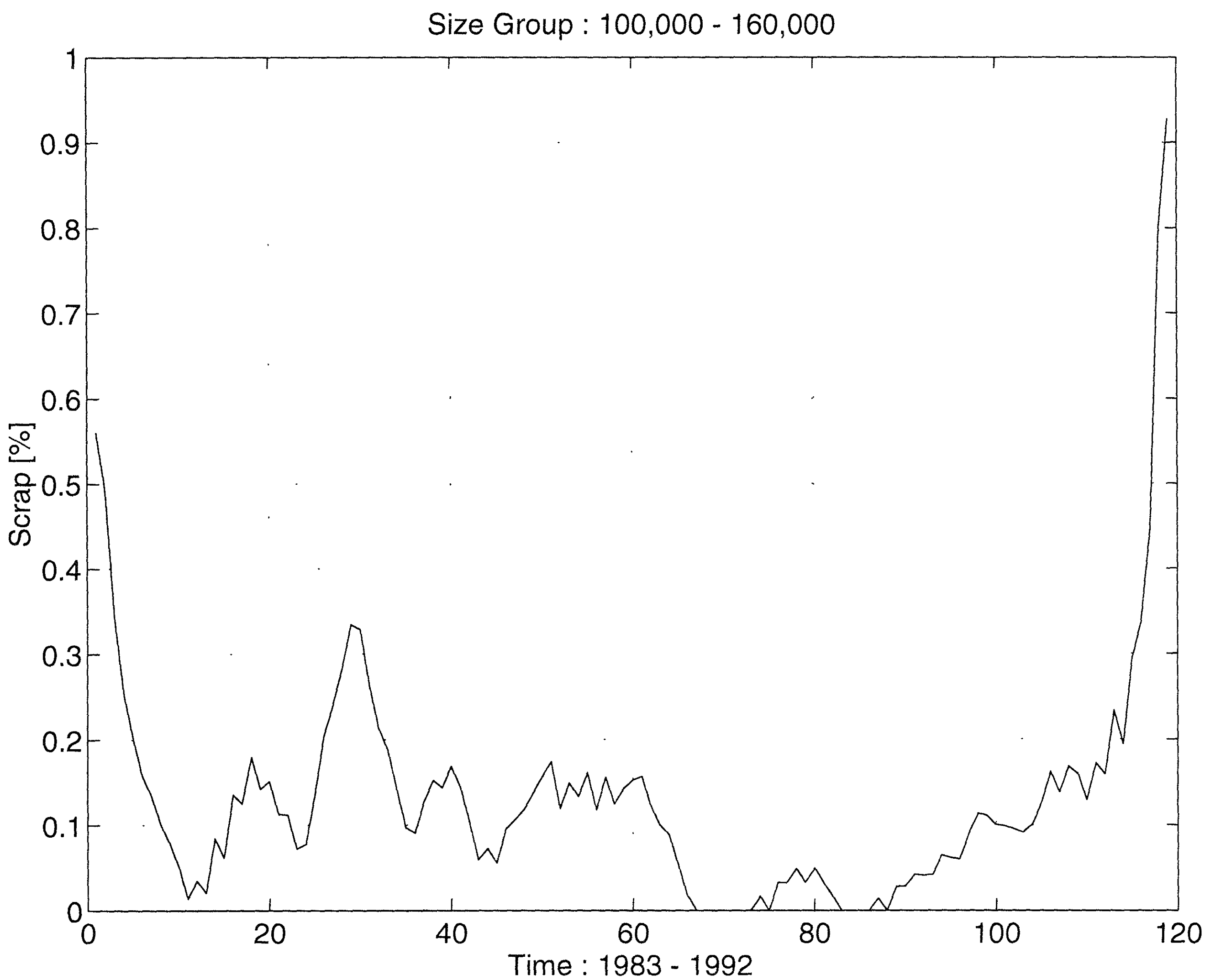


Figure 2-9: Percentage of Size Group Capacity Scrapped

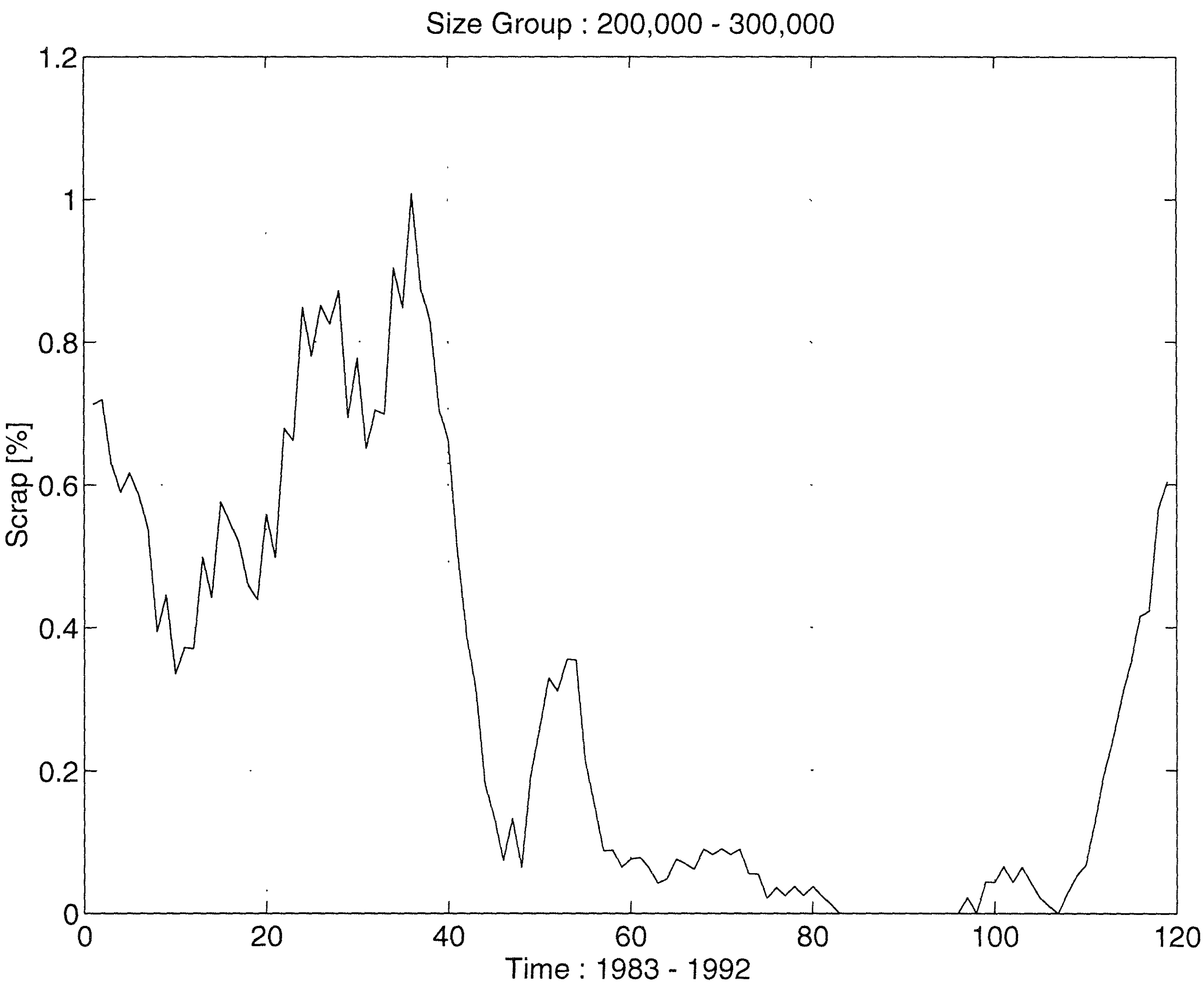


Figure 2-10: Percentage of Size Group Capacity Scrapped

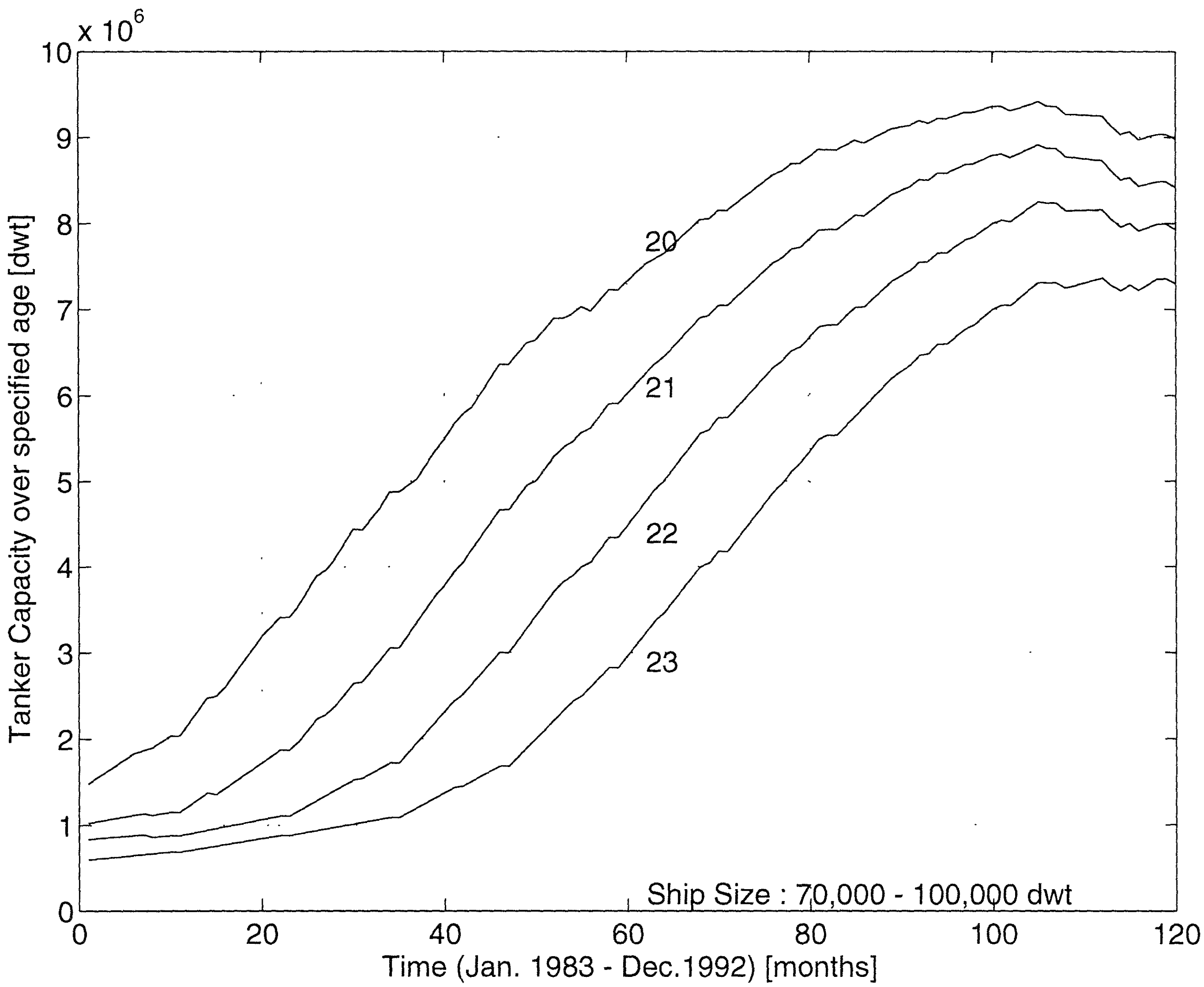


Figure 2-11: Capacity of "aged" fleet

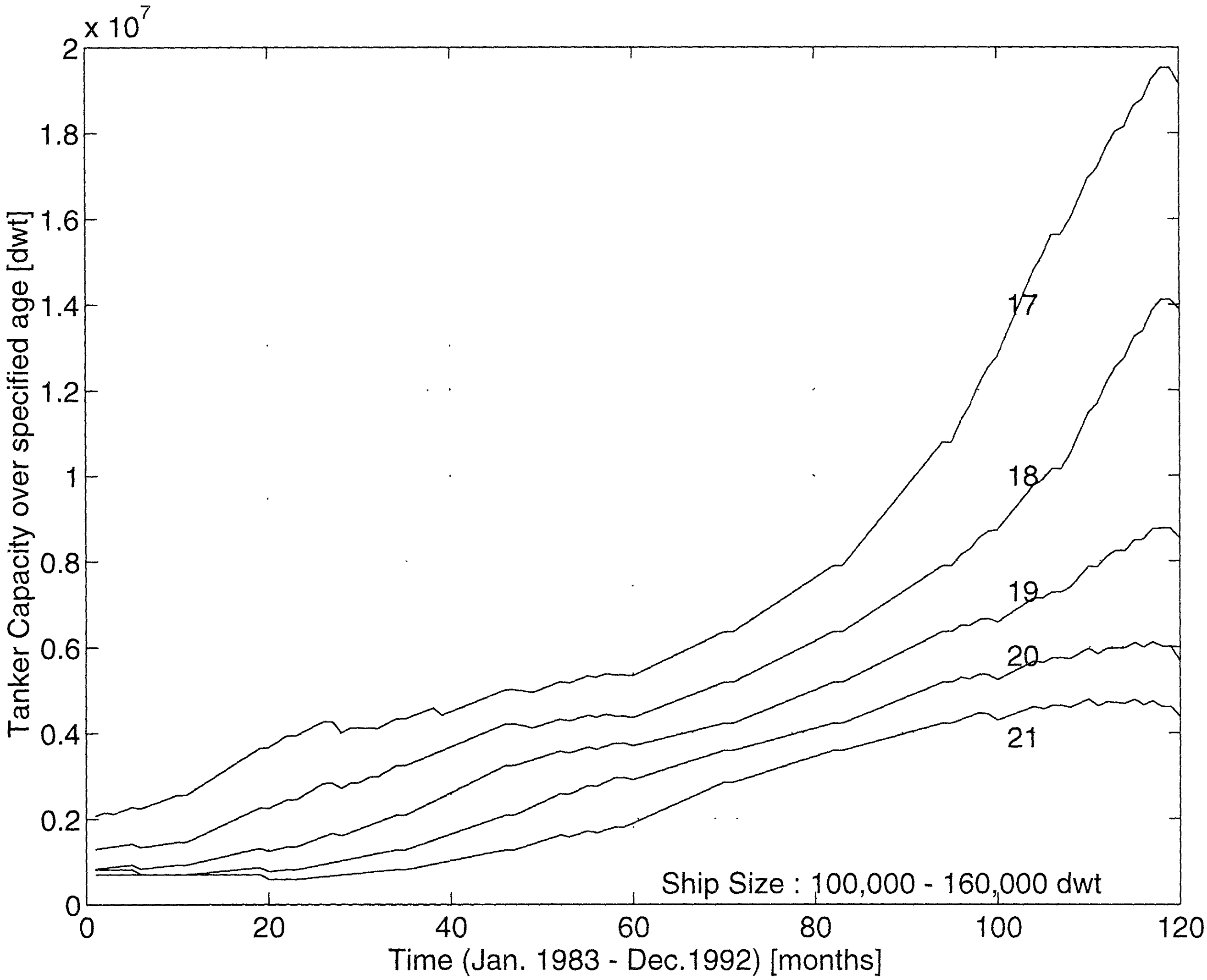


Figure 2-12: Capacity of "aged" fleet

2.4 Freights

2.4.1 Qualitative Analysis.

Regarding ships of same size, freights, behave in a similar way -more or less- for different routes (in WS terms). In long term they follow the same trend. Factors that may differentiate freights are:

1. Ports with limited draught. Thus, on large tonnage ships (medium tankers, ULCC's and VLCC's), competition is restricted between ships designed with smaller draught than the optimum one (for fuel efficiency). Of course other techniques may be used such as ships to dock at restricted draft terminals; they often either have to part-load or lighten before entering (lightering). Offshore pipelines running miles away from coast may be used as well (such as LOOP - Louisianna offshore oil pipeline , or mother ship may unload to smaller ships.).

2. In short term, freights may change substantially, as what defines freight rates is the number of tankers available in the proximity of the region of interest (oil producing country). Thus, an otherwise inexplicable jump or drop may be present in freights for this route. As it take less than a month to cover a local surplus in tanker demand by moving in tankers from other markets, the jump in freights will not be seen for a period more than a month (at most two). The same can not be said for markets with surplus in supply (large availability in tonnage). Shipowners are willing to wait for "better days" (higher transportation capacity demand) or to see someone else taking the burden of moving from one market to another.

3. For small and medium size tankers, it may be observed that freights do not present so many ups and downs as for VLCC's and ULCC's. This may be due to the influence of combined cargo tankers. Combined cargo tankers are willing to leave the oil market and jump into the dry bulk market if they see a low rate of freights in the tanker market (and vice versa). So, the portion of idleness will drop, driving freights up (or down, in a reverse situation). This "stability factor" does not affect the market of ULCC's and VLCC's as there are not any combined tankers with such a large size. The flexibility of supply offered by combined carriers can be gauged by the fact that, at the peak of the market in 1973, these ships added almost 50% to

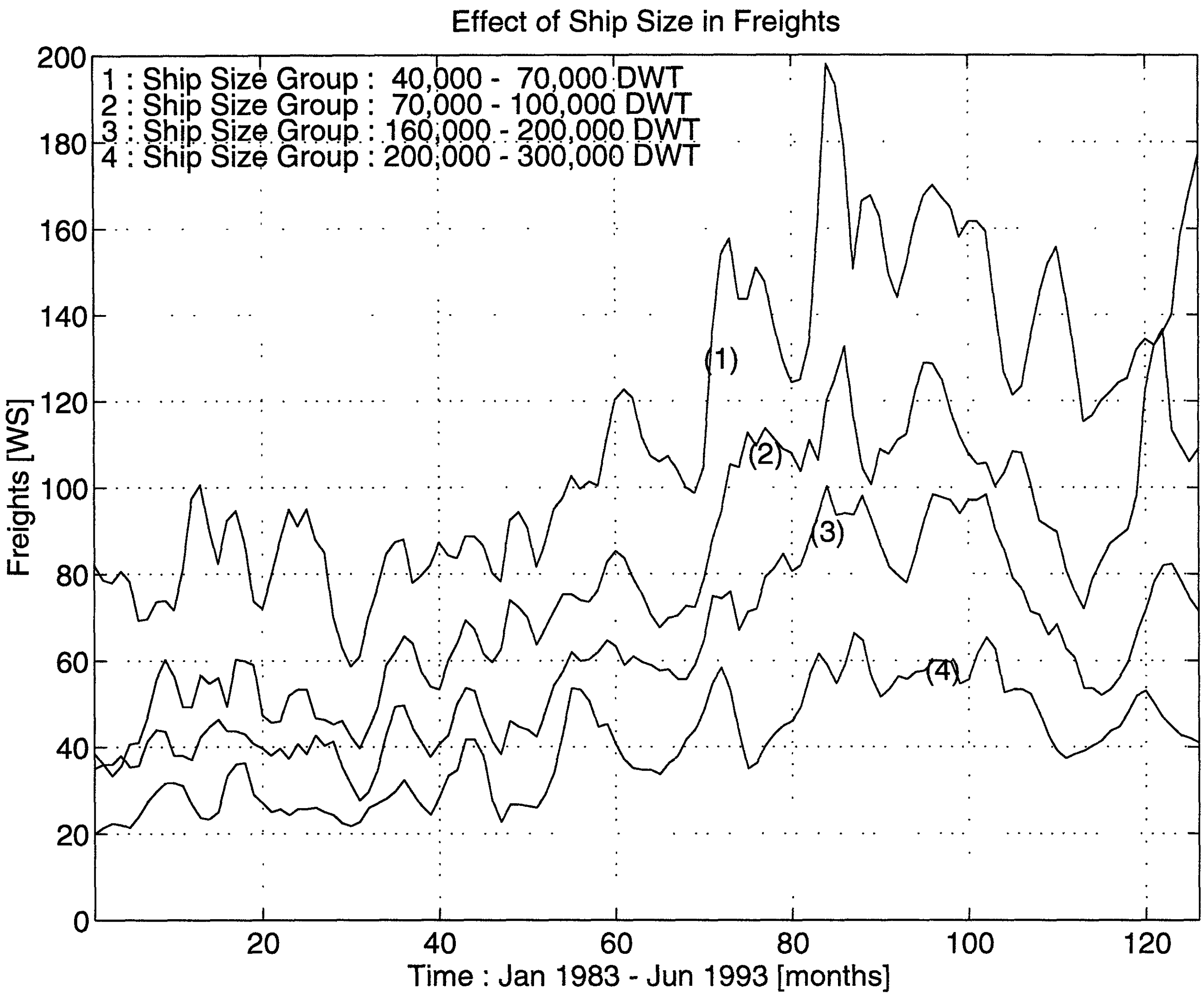


Figure 2-13:

tanker supply, but in 1981 they added only 10% [1].

4. In addition the ship's draft another parameter that may exclude some ships from being part of competition in certain routes is ship's breadth. Such a characteristic route is Alaska-U.S.E.S. Tanker designs away from the optimum (fuel consumption for given transportation capacity) are very common at the area of 70,000 DWT (PANAMAX), so that they are able to travel via Panama Canal.

5. As it is expected, the larger the size of ship, the lower its freight (in W.S.) due to scale economies (see Figure 2.13 for the effect of ship size in freight rates).

6. During recessionary periods , shipowners are ready to accept lower rates for longer voyages. This is due to the fact that they avoid risk of unemployment - which is very high during recessionary periods - for longer time. The adverse phenomenon should be expected when demand for transportation capacity increases. Also shipowners are willing to accept lower freight rates when the port of call is close to a region with high chartering activity. This is true specially during recession periods (see Figures 2.15 and 2.16).

7. Also we have to consider the effect of idleness of larger and/or smaller tanker ships on the category of ships (according to its DWT) under investigation.

8. Other restrictions may apply in certain routes. For example only U.S. flag ships (ships operating under the "Jones Act" to be more specific) may serve the route Alaska - U.S.W.S. or U.S.E.S.

9. Competition from other sizes: according to a Drewery's report [1], medium-sized tankers (80,000 - 140,000 DWT) compete with ships smaller than themselves on virtually all routes, but there are a few important trades where the competition is of particular importance. These are noted in the following table:

TRADE	1983 EMPLOYMENT OF MEDIUM TANKERS (million DWT)	COMPETING SHIP SIZE
North-Europe-North Europe	2.4	Smaller
North Africa-South Europe	2.0	Smaller
Carribean-USES	1.2	Smaller
East Med. -South Europe	1.8	Smaller
A.G.-South Europe (C/C)	0.3	VLCC
Carribean-North Europe	0.6	Smaller
North Africa-USES	0.3	Smaller
E.Europe-South Europe	1.0	Smaller
Alaska-USWC	0.7	VLCC
Alaska - Panama pipeline	0.6	VLCC
North Europe - USES	0.8	Smaller

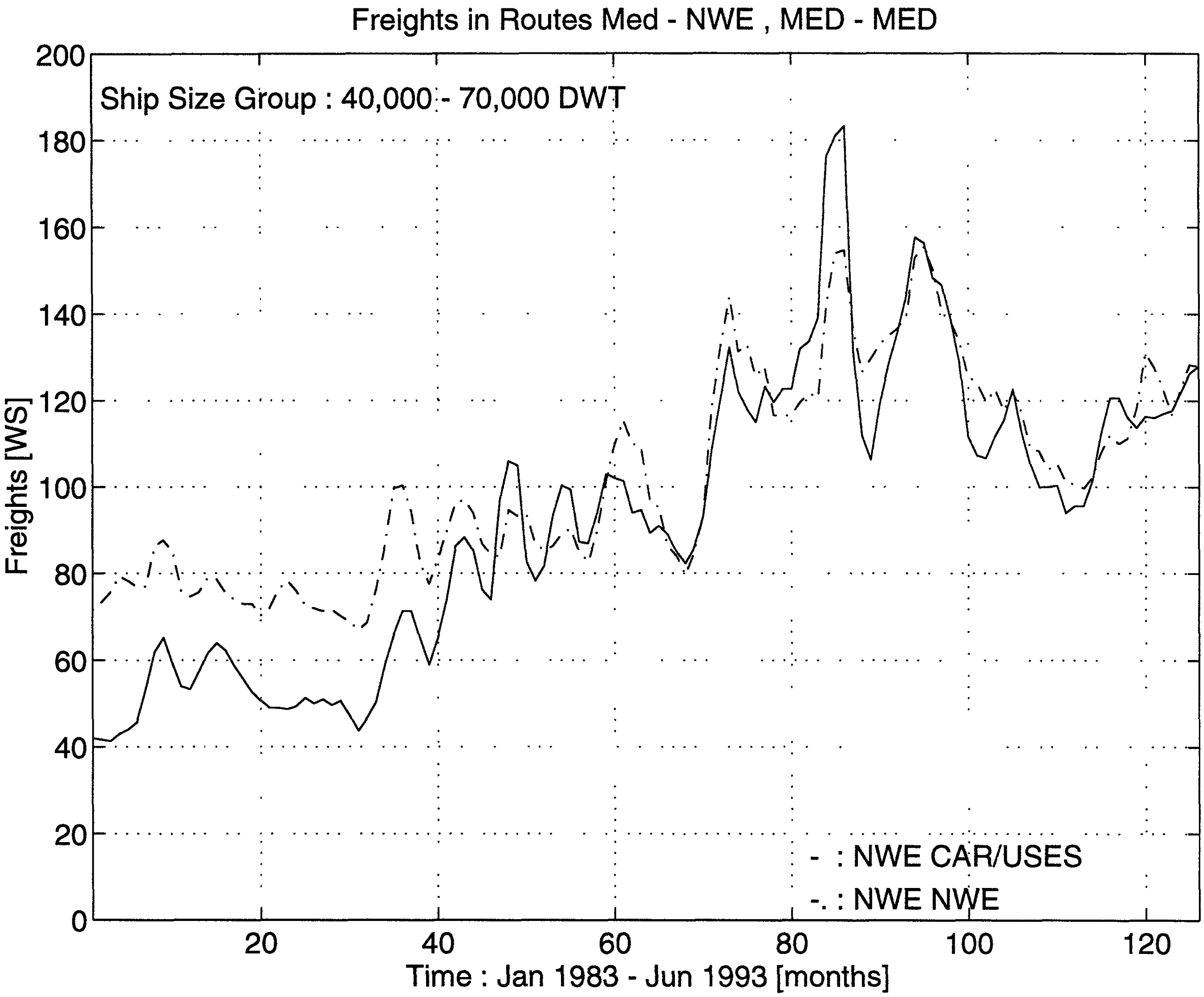


Figure 2-14: Different freight rates during recession.

Competition on these trades will be in the form on new fuel-economy 60 and 80,000-tonners and from surplus VLCC's.

In Figures 2.18 - 2.22 we can see trade routes for which freight rates behave the same.

DESCRIPTION OF PROCEDURE

In the third part of our analysis, we have tried to forecast freight rates when idleness of the fleet is assumed given. Fleet was divided in four size groups, same as in the previous steps of our analysis:

1. 40,000 - 70,000 dwt
2. 70,000 - 100,000 dwt

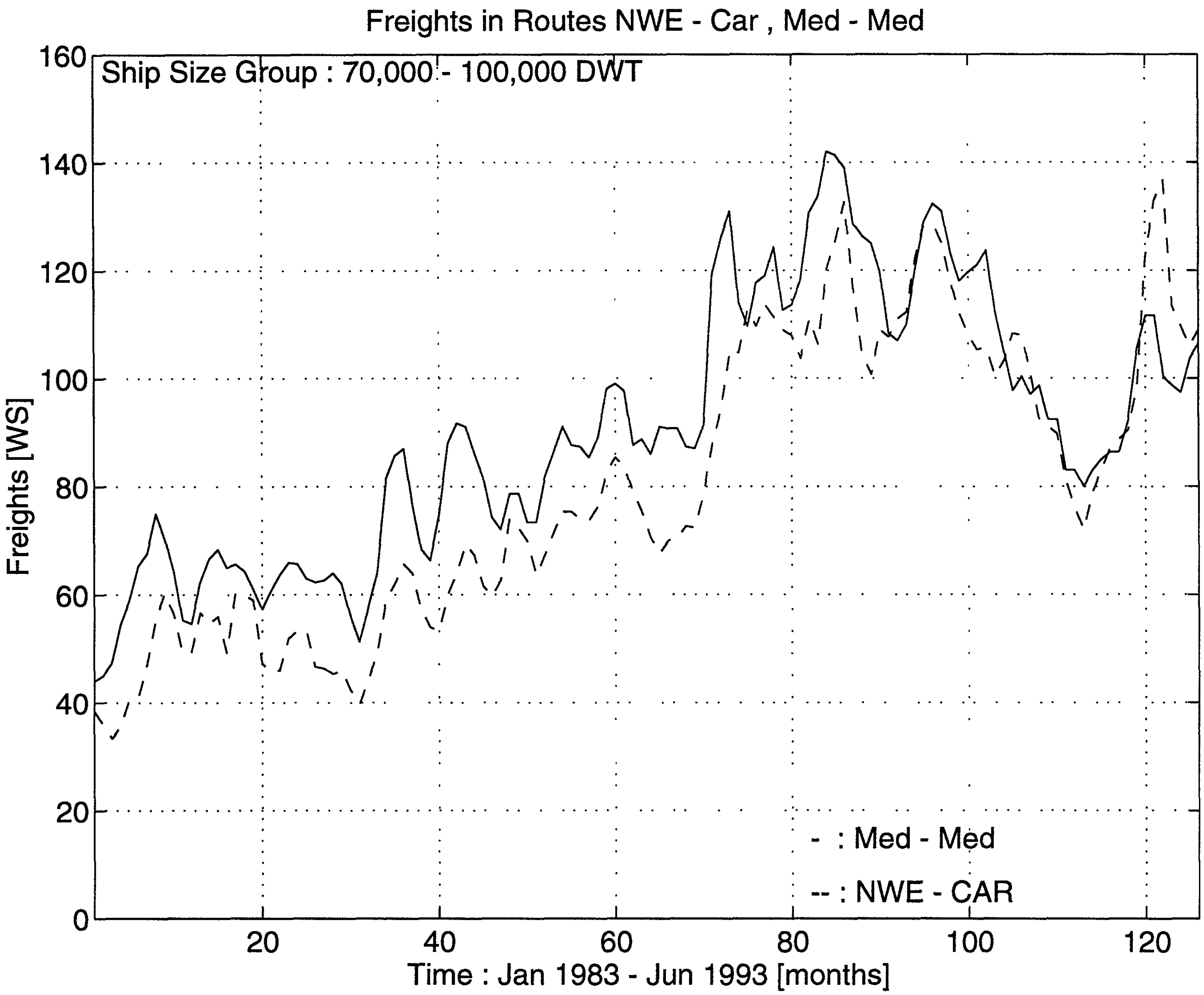


Figure 2-15: Different freight rates during recession.

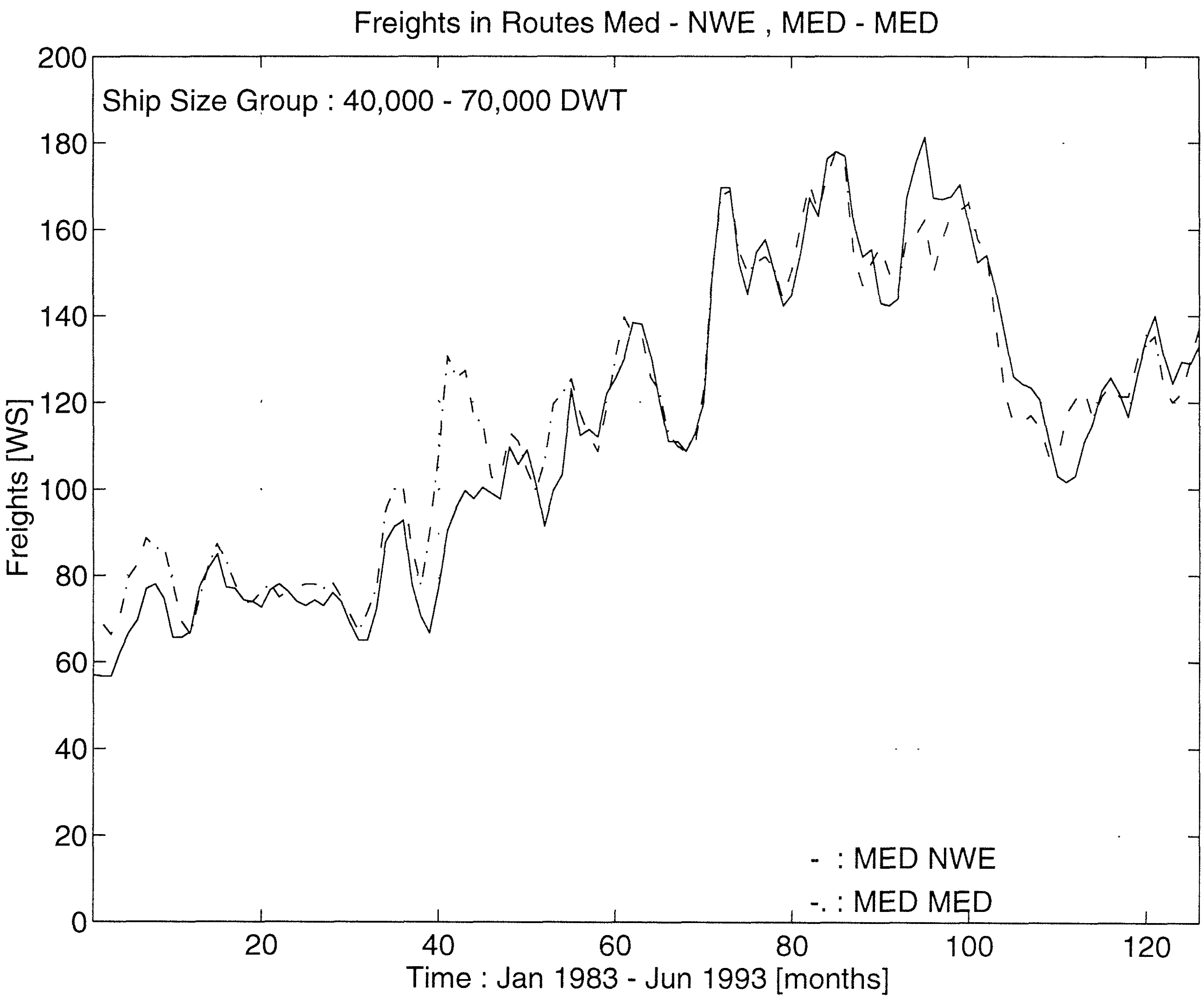


Figure 2-16: Freight Rates show agreement

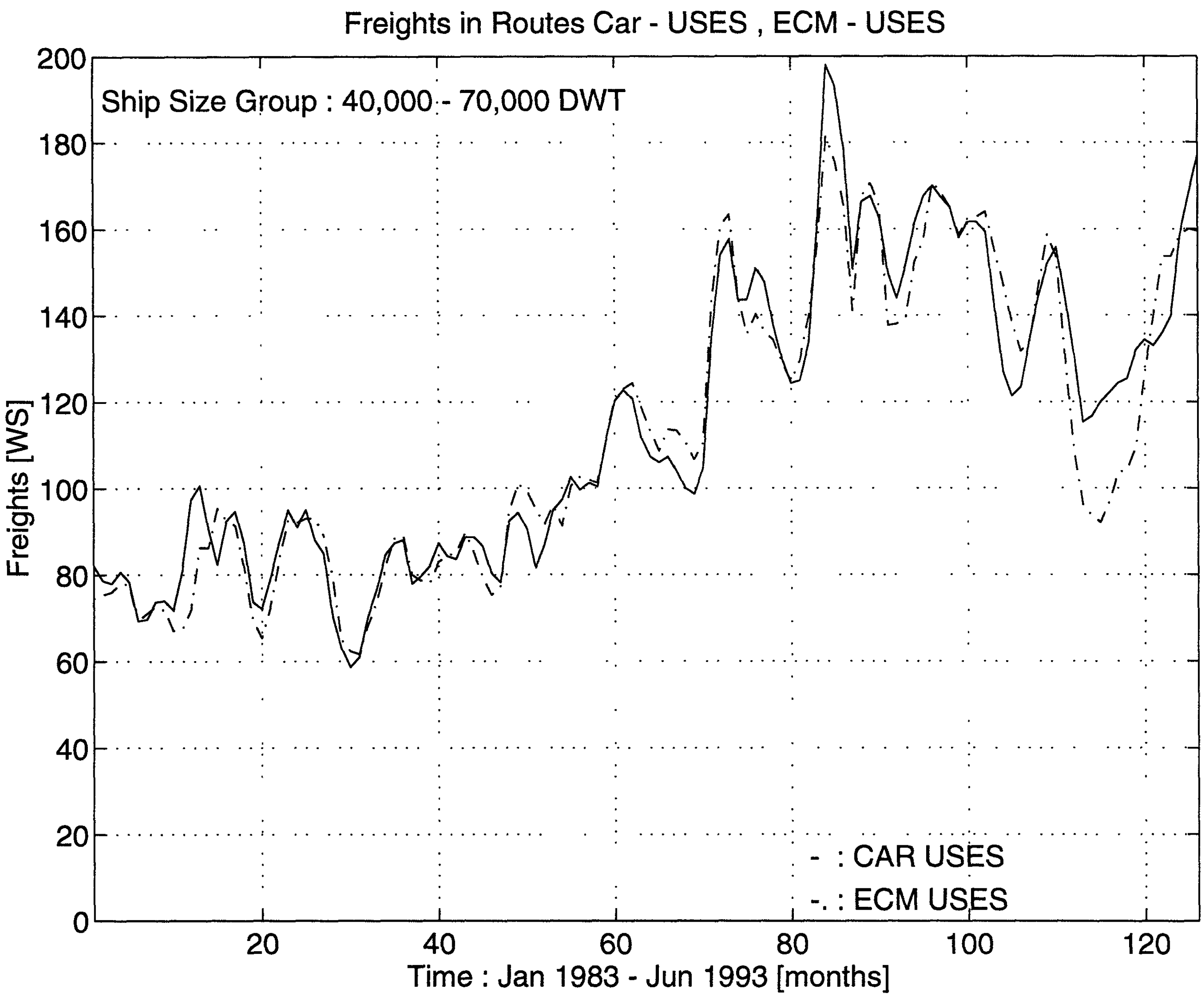


Figure 2-17: Freight Rates show agreement

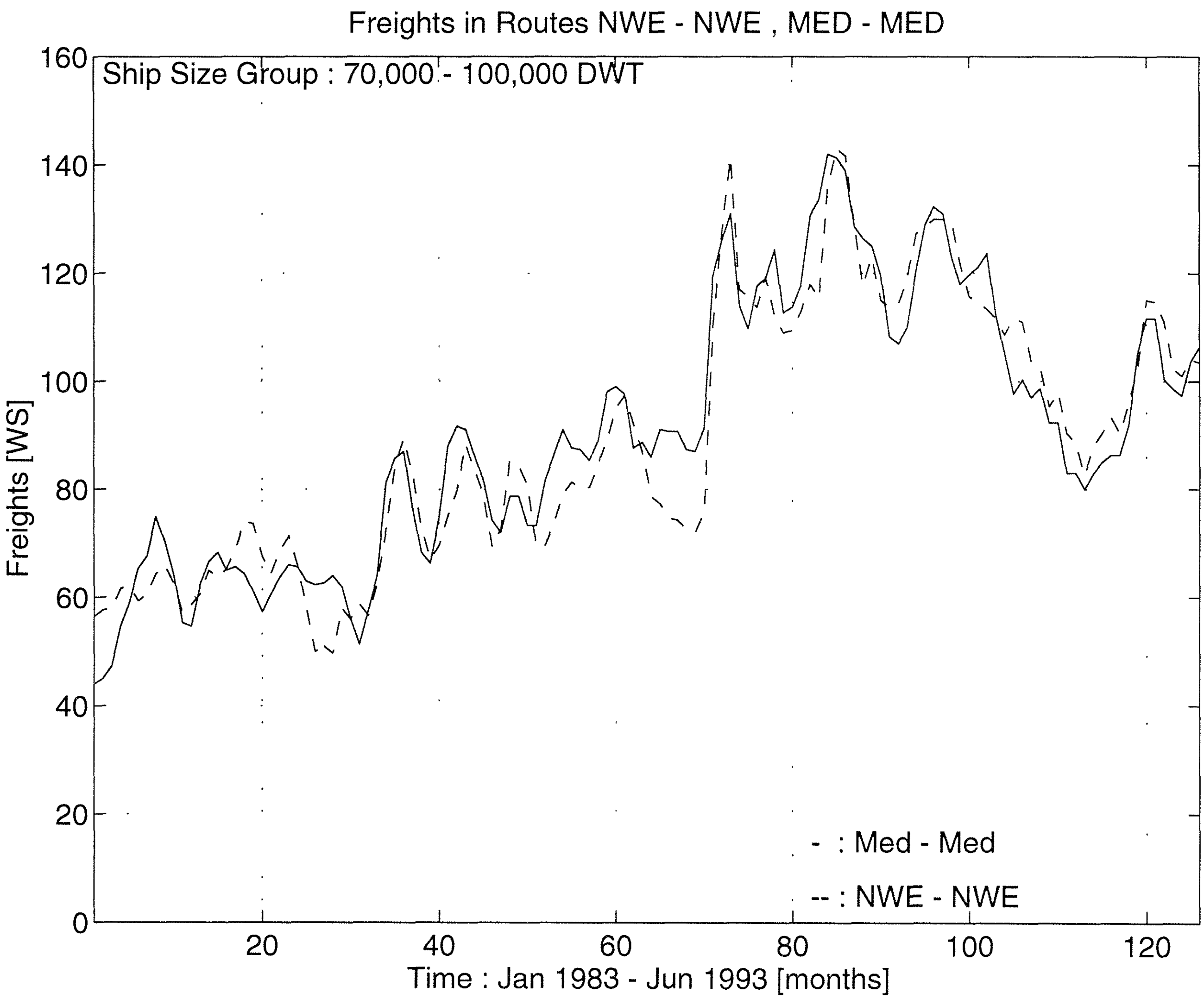


Figure 2-18: Freight Rates show agreement

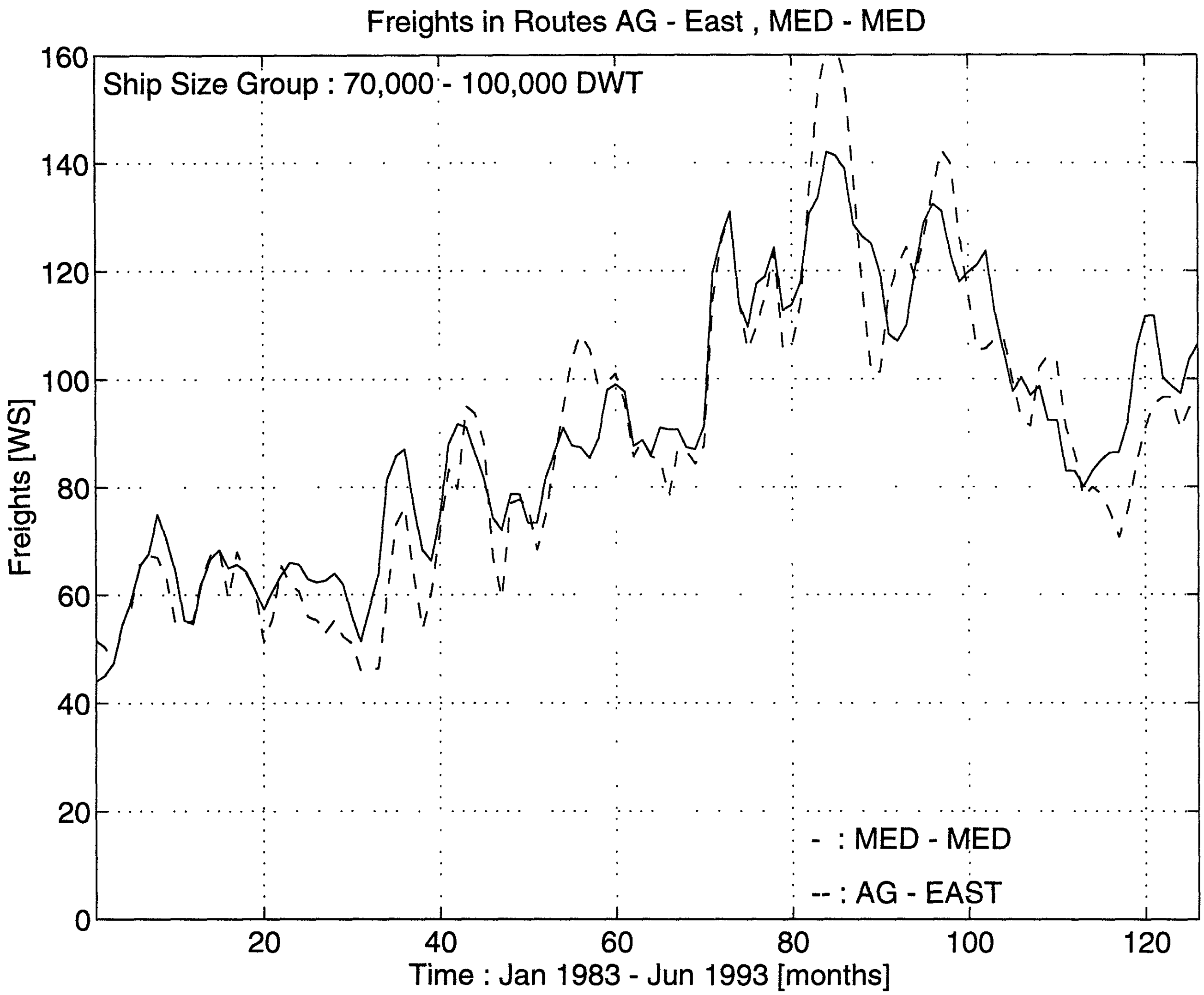


Figure 2-19: Freight Rates show agreement

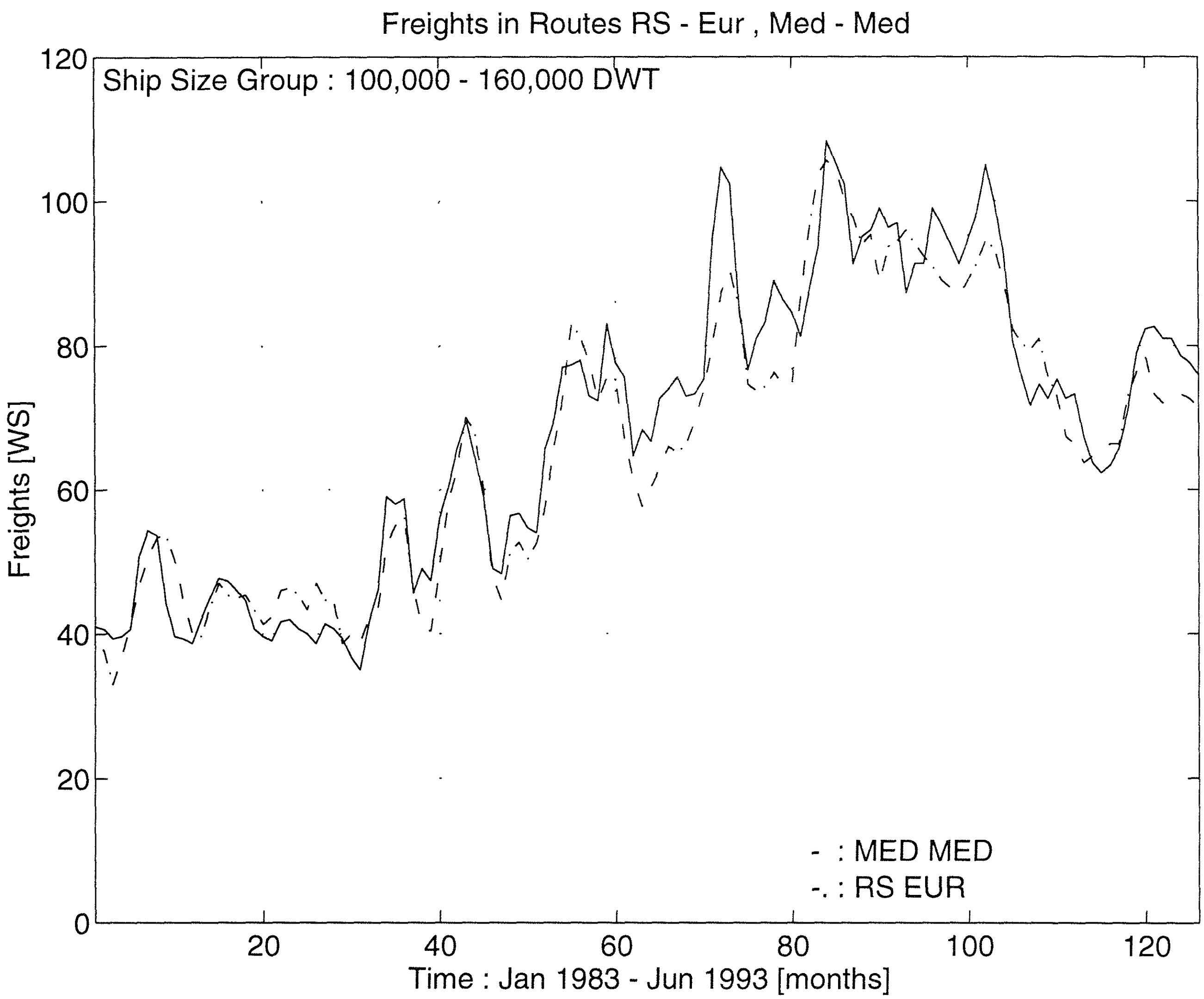


Figure 2-20: Freight Rates show agreement

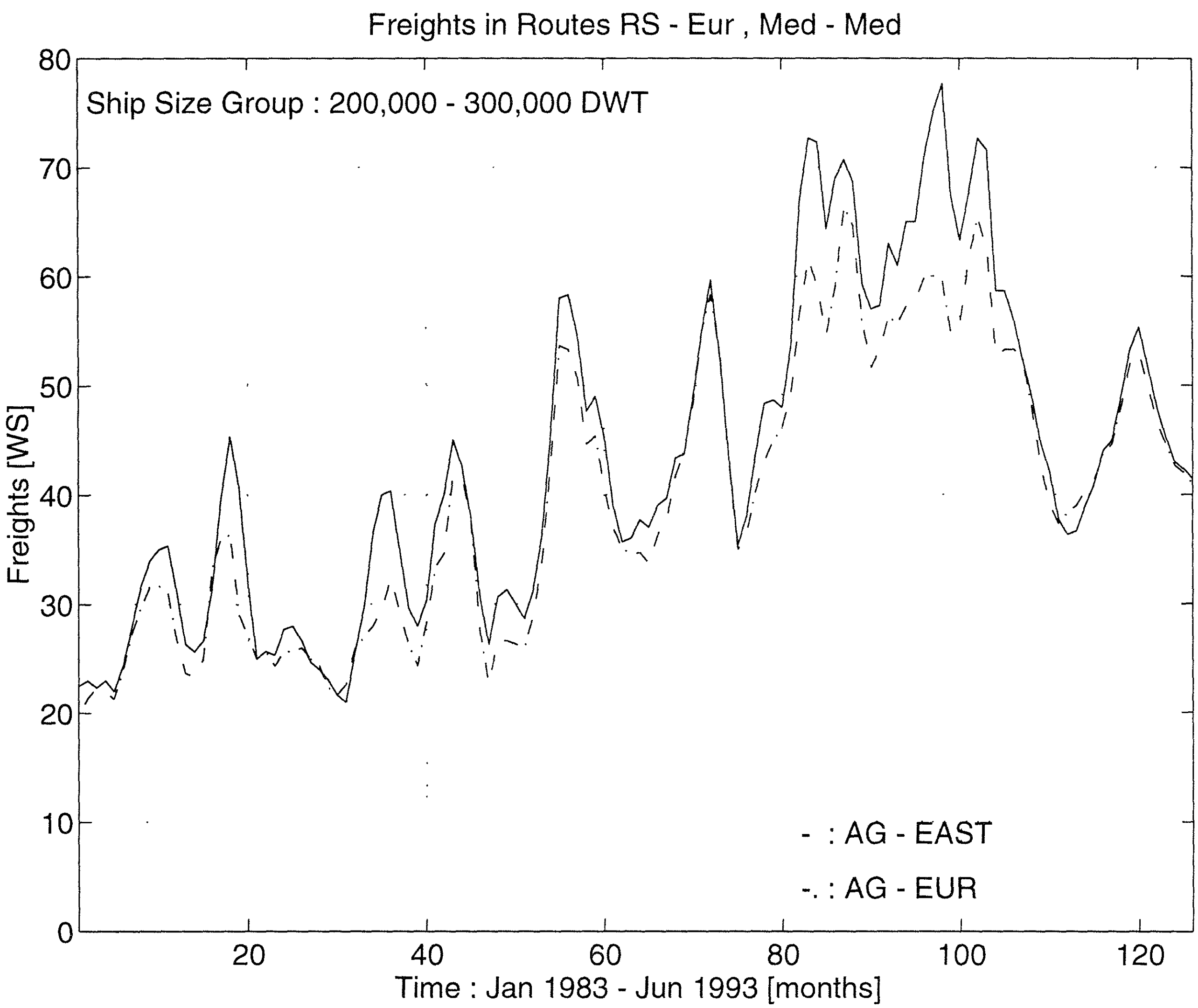


Figure 2-21: Freight Rates show agreement

3. 100,000 - 160,000 dwt
4. 200,000 - 300,000 dwt

The derived data covers a period of 10.5 years (126 months) from January 1983 till June 1993.

In our investigation we examined the influence of the idleness of a group on the freights prevailing in the same ship size group. Also we examined the impact on freight rates of one group due to the idleness of other ship size groups. In most cases such a relation was observed, and in some cases such an influence was even higher than the impact on freights due to idleness of the same size group.

Finally we examined the time - series for existence of time-lag. We compared freight rates with idleness shifting idleness values one,two and three months in both directions (towards the future and towards the past). Although in most of the cases such a time lag seemed to exist, if each route was treated as an individual case, no main pattern that could characterize all trade routes seemed to exist.

In Figures 2.22 and 2.23, we may notice two idleness thressholds which are related with oversupply and overdemand.

On what it concerns oversupply, by the term Idleness Threshold we mean the idleness percentage of the fleet, above which freight rates reach a lower limit shipowners will accept, thus being insensitive to inactivity levels. This lower limit in freight rates is defined as operating cost minus lay-up cost.

On what it concerns overdemand, by the term Idleness Threshold, we mean the idleness percentage below which no relation between supply and demand exists as "panic buying" prevails. Shipowners may ask whatever freight rates they wish and charterers have no other choice than to accept, as the belief is that tomorrow freight rates will inrease even more.

For each size group neither the idleness thresholds nor freight rates (in WS) are the same. Plotting freights rates versus idleness (as in Figures 2.23 and 2.24) we may form the following table:

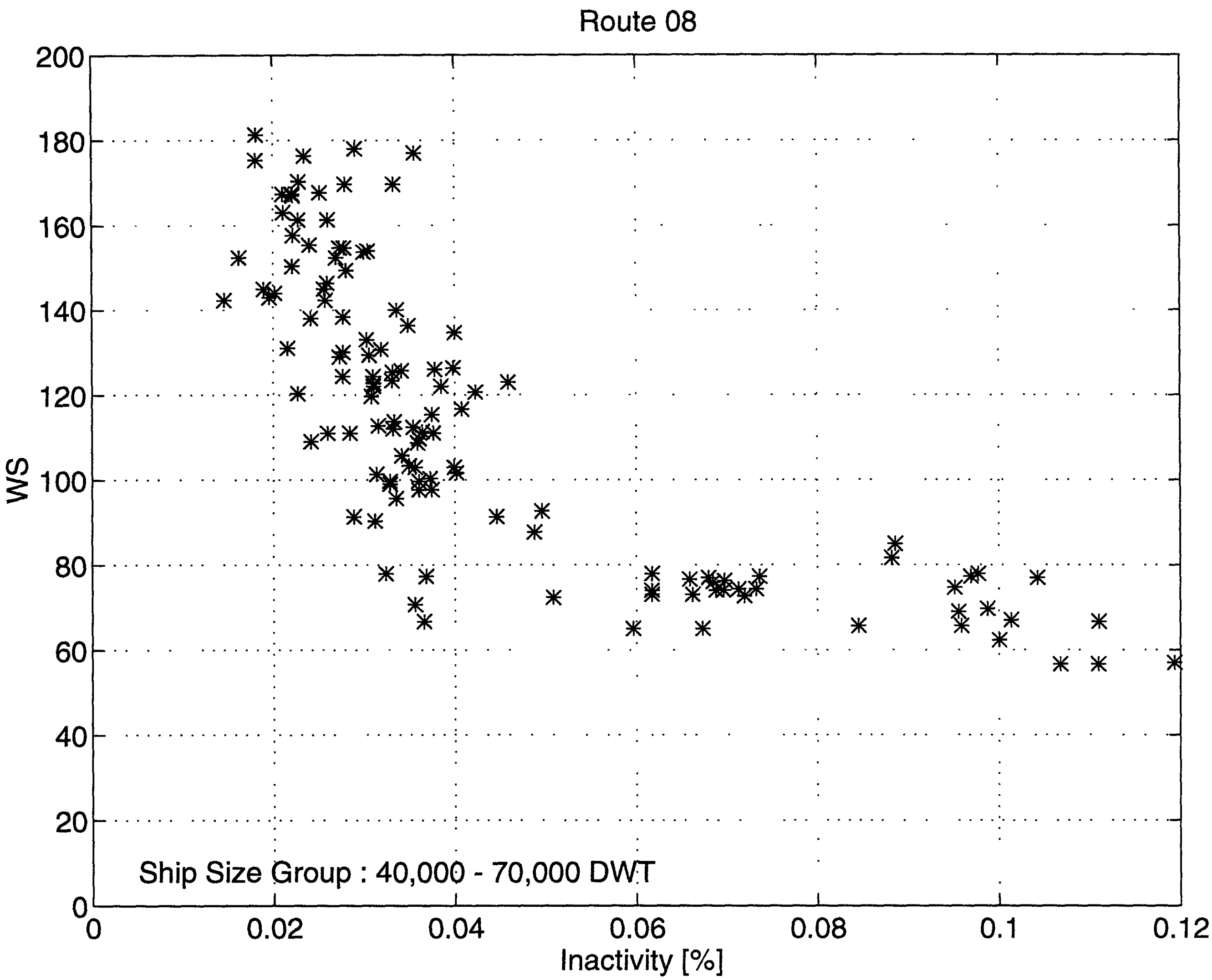


Figure 2-22: Freight Rates vs. Inactivity

Ship Size Group (thousands DWT)	Idleness Thresholds Oversupply - Overdemand	Rates (WS)
40 - 70	2.5% - 5%	62
70 - 100	4% - 7%	60 45
100 - 160	12.5% - 30%	37
200 - 300	12.5% - 32%	22

As we can see in the figures, freights corresponding in recession periods may vary (as well as in other periods). This may be caused:

- High insurance costs due to war in major oil-producing countries.

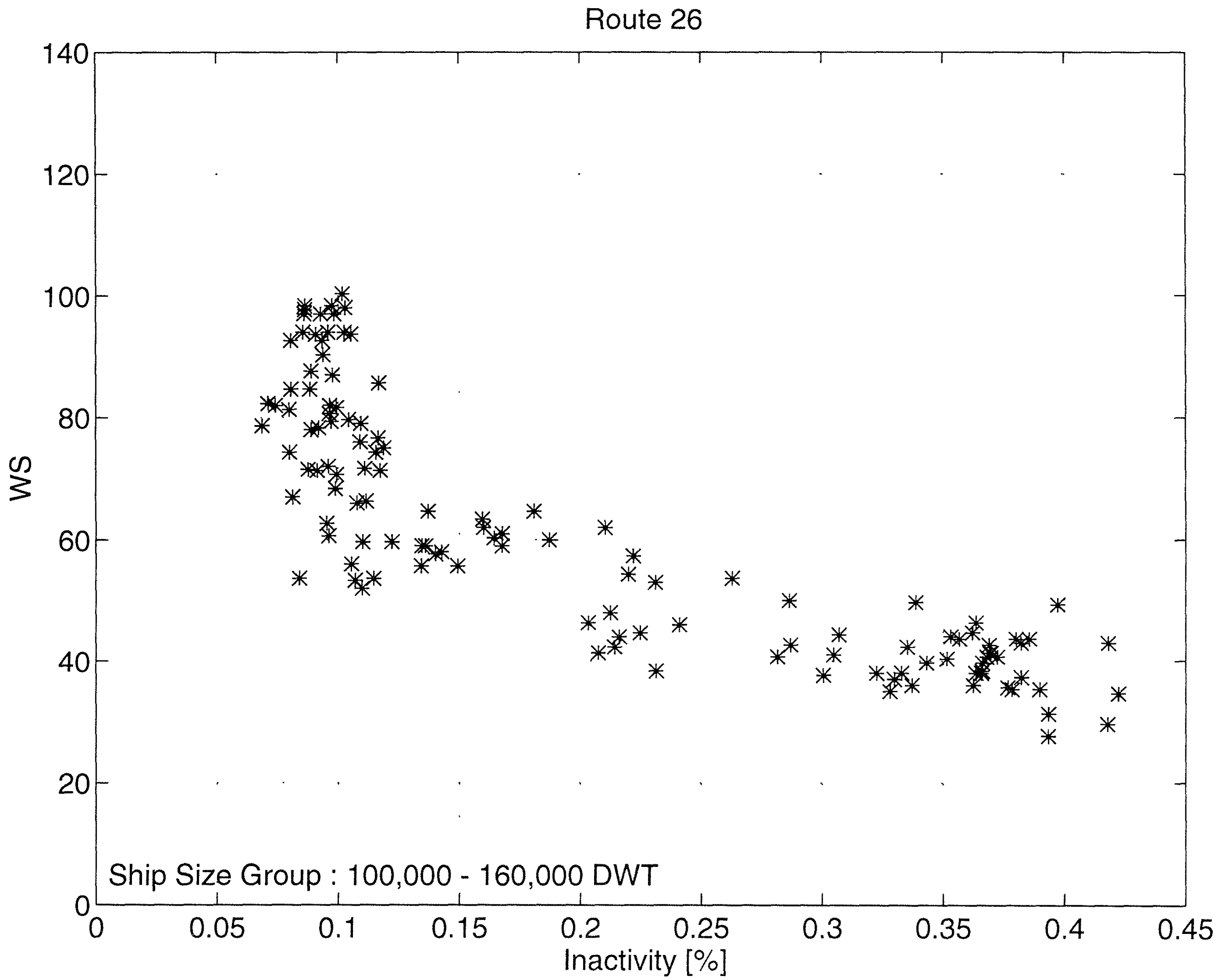


Figure 2-23: Freight Rates vs. Inactivity

- Wide variation of ship sizes even in the groups we have defined. Therefore a difference in freights is expected.

- A shipowner will add a premium to the ship freight rate when unemployment percentage is on a decline. Therefore expectations for the future rates should also be considered.

2.4.2 Quantitative Analysis - Results

The freight rates for ship sizes 40,000 - 70,000 dwt, in the routes with destination USES is heavily dependent to the employment of the larger size group (200,000 - 300,000 dwt). This may be due to the fact that smaller ships are used for the lightering of the larger ones. Also employment on both size groups is influenced from the same factors i.e. industrial production of the industrialized countries.

For the other routes, their main characteristic is their small voyage duration, which invokes a large ratio of days in port over round trip duration. When such a high ratio is observed, routes are not profitable for VLCC's and smaller ships do not affront their competition.

***** 40,000 - 70,000 ****************************

Route 03 CAR USES observations : 126

$WS = 212.3347 - 815.4292 * I_4 + 250.5539 * I_4^2$

$R_{adj} = 0.7967$

Time lag: 2 months.

Route 07 ECM USES observations : 126

$WS = 205.0527 - 757.5117 * I_4 + 227.2120 * I_4^2$

$R_{adj} = 0.7672$

Time Lag: no time lag was observed.

Route 08 MED NWE observations : 126

$WS = 212.7 - 3.3387 * i1 + 0.8277 * i1^2$

$R_{adj} = 0.7004$

Time Lag: no time lag was observed.

Route 09 MED MED observations : 126

$WS = 208.7 - 3.1107 * I_1 + 0.7756 * I_1^2$

$R_{adj} = 0.7285$

Time Lag: 2 months.

Route 16 NWE NWE observations : 126

$WS = 171.1 - 2.4027 * I_1 + 0.6364 * I_1^2$

$R_{adj} = 0.5982$

Time - Lag: 1 month.

Route 17 NWE CAR/USES observations: 126

$WS = 144.0096 - 248.5824 * I_4$

$R_{adj} = 0.7711$

Time Lag: no time lag was observed.

***** 70,000 - 100,000 ***

Concerning trade routes served from ships of sizes 70,000 - 100,000 DWT, we may conclude that they are strongly influenced from competition of smaller size vessels. No safe conclusion may be derived for the trade routes Carribean-Europe and Red Sea-Europe as the fit of regression analysis is low. For this routes data covers a period of 7 years -from 1986 to 1992- instead of 10.5 years. The disturbance caused by Kywait War may be the cause of such poor fit in regression analysis.

Route 05 Carribean - USES observations: 126

$WS = 165.4 + 465.4 * I_2 - 2969.9 * I_1 + 606.8 * I_1^2$

$R_{adj} = 0.5884$ High competition from smaller ships

Time lag : 1 month.

Route 06 Carribean - Europe observations: 126

$WS = 113.5 + 0.8527 * I_2 - 3136.4 * I_1 + 1240.1 * I_1^3$

$R_{adj} = 0.2312$ High competition from smaller ships.

Time lag : 2 months . Surprisingly how much it affects accuracy of prediction.

Route 12 MED MED observations: 126

$WS = 139.0 + 602.2 * I_2 - 1608.0 * I_1 - 344.5 * I_1^2$

$R_{adj} = 0.5860$

High competition from smaller ships.

Time lag : two months.

Route 18 NWE NWE observations: 126

$WS = 146.6 + 202.6 * I_2 - 2139.8 * I_1 + 462.4 * I_1^2$

$R_{adj} = 0.5909$

Time Lag : no time lag was observed.

Route 19 NWE CAR observations: 126

$WS = 137.5 + 394.2 * I_2 - 2305.2 * I_1 + 420.0 * I_1^2$

$R_{adj} = 0.6258$

Time Lag: no time lag was observed.

Route 30 AG EAST observations: 126

$WS = 162.1 - 2536.5 * I_1 + 650.7 * I_1^2$

$R_{adj} = 0.5769$

Very high influence from smaller ships (parallel market)

Time Lag : 2-3 months.

Route 41 RS EUR observations : 90

$WS = 144.4 + 552.4 * I_2 - 1553.1 * I_1 - 393.4 * I_3$

$R_{adj} = 0.3441$

Time lag : 2 months (explained much better with time - lag).

*********** 100,000 - 160,000 ****************************

For vessels that belong to this size group, we observe a very good fit of the estimated freights from the regression analysis if the idleness of the largest ship size group is used. If unemployment of the 100,000 - 160,000 dwt group is used instead, the fit of regression is very poor (giving R^2_{adj} lower than 0.2). This may be due to the fact that ships on both groups compete each other and the freight rates are defined from what happens on the largest one, as it represents higher transportation capacity. (92.8 million dwt for group No.4 and 35.8 million dwt for group No.3).

Route 14 MED MED observations : 126

$WS = 108.8431 - 183.3958 * I_4$

$R_{adj} = 0.7574$

Time Lag: no time lag was observed.

Route 15 MED NWE observations : 78

R_{adj} was very low (less than 0.4).

Route 25 WA EUR observations : 90

$WS = 101.6359 - 207.3427 * I_4$

$R_{adj} = 0.5215$

Time Lag: no time lag .

Route 26 WA CAR/USES observations : 126

$WS = 90.1930 - 144.9220 * I_4$

$R_{adj} = 0.7131$

Time Lag: no time lag was observed.

Route 32 AG EAST (FE) observations : 90

$WS = 176.2065 - 975.9518 * I_4 + 418.7162 * I_4^2$

$R_{adj} = 0.6189.$

Time Lag: no time lag was observed.

Route 33 AG EUR observations : 126

$WS = 86.4849 - 114.217 * I_4$

$R_{adj} = 0.7016$

Time Lag: no time lag was observed.

Route 42 (RS MED) RS EUR observations : 126

not to take off gulf war (shipments from Red Sea)

$WS = 99.6279 - 150.6878 * i4$

Radj= 0.7145

Time Lag: no time lag was observed.

************* 200,000 - 300,000 DWT ******************************

Route 35 AG EAST (FE) 200-300

$WS = 20.9 + 58.4646 * exp(-6.3946 * I_4)$

$R_{adj} = 0.6369$

Time Lag : no time lag.

Route 36 AG EUR

$WS = 19.9 + 52.3546 * exp(-6.3103 * I_4)$

$R_{adj} = 0.6798$

Time Lag : no time lag.

2.4.3 Validation Tests

Considering the industrial production of the U.S.A., Japan and O.E.C.D. as given for the 12 months of the 1993, as well as the newbuildings expected to be delivered in the same time period, we derived the expected freight rates from the above formulas. Results show agreement with the actual freight rates, as it is shown in the next figures.

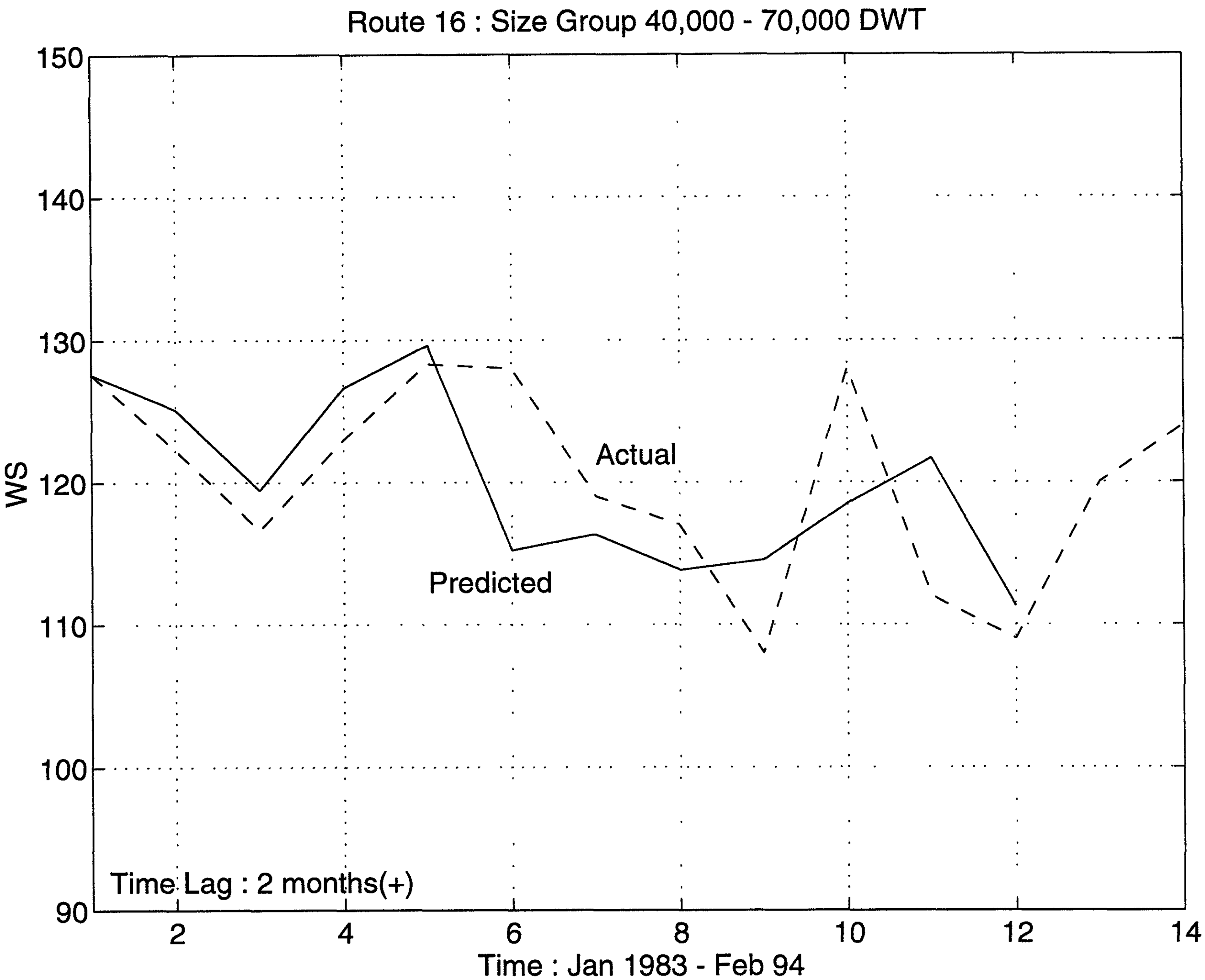


Figure 2-24: Freight Rates in Route NWE-NWE.

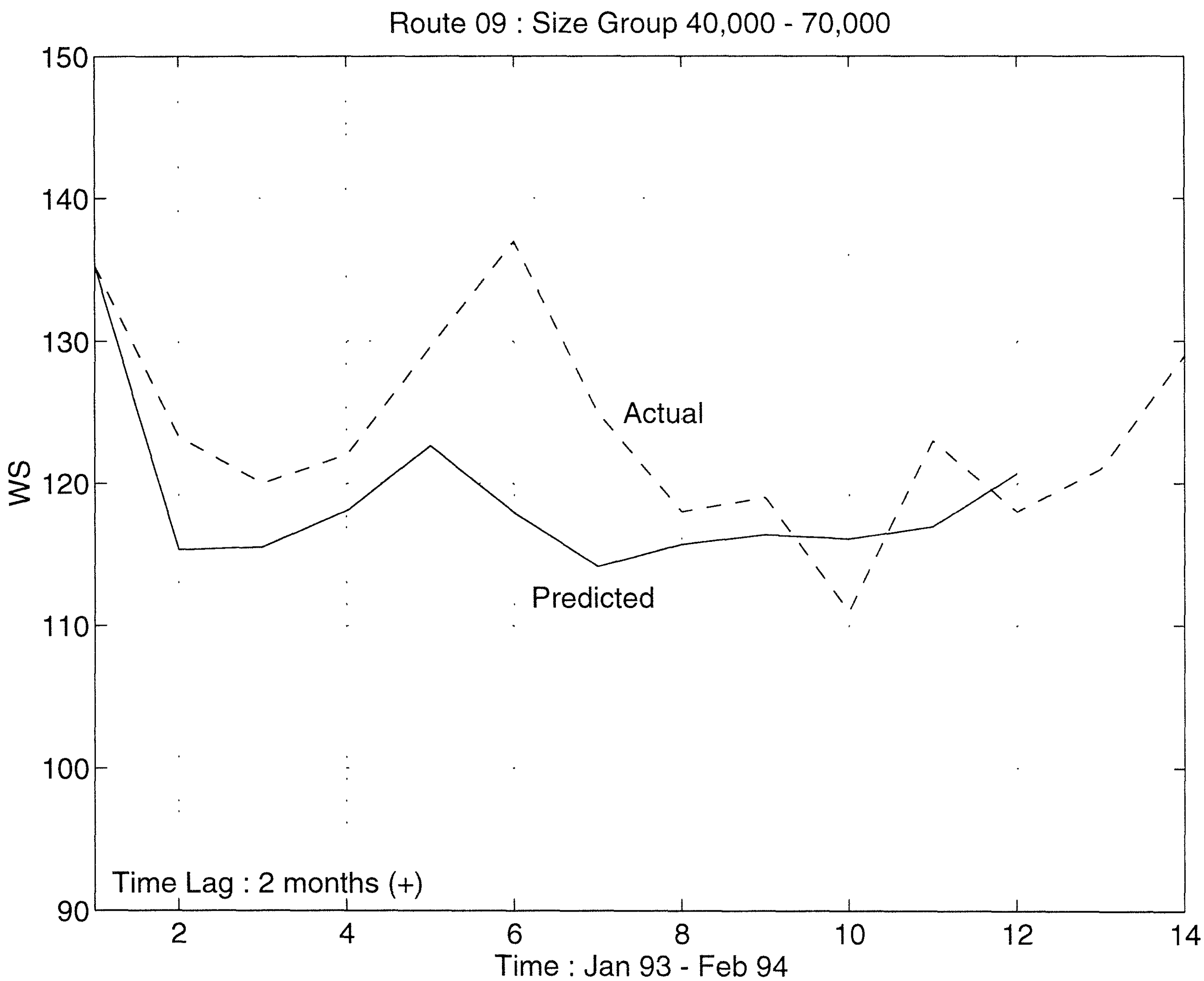


Figure 2-25: Freight Rates in Route MED-MED.

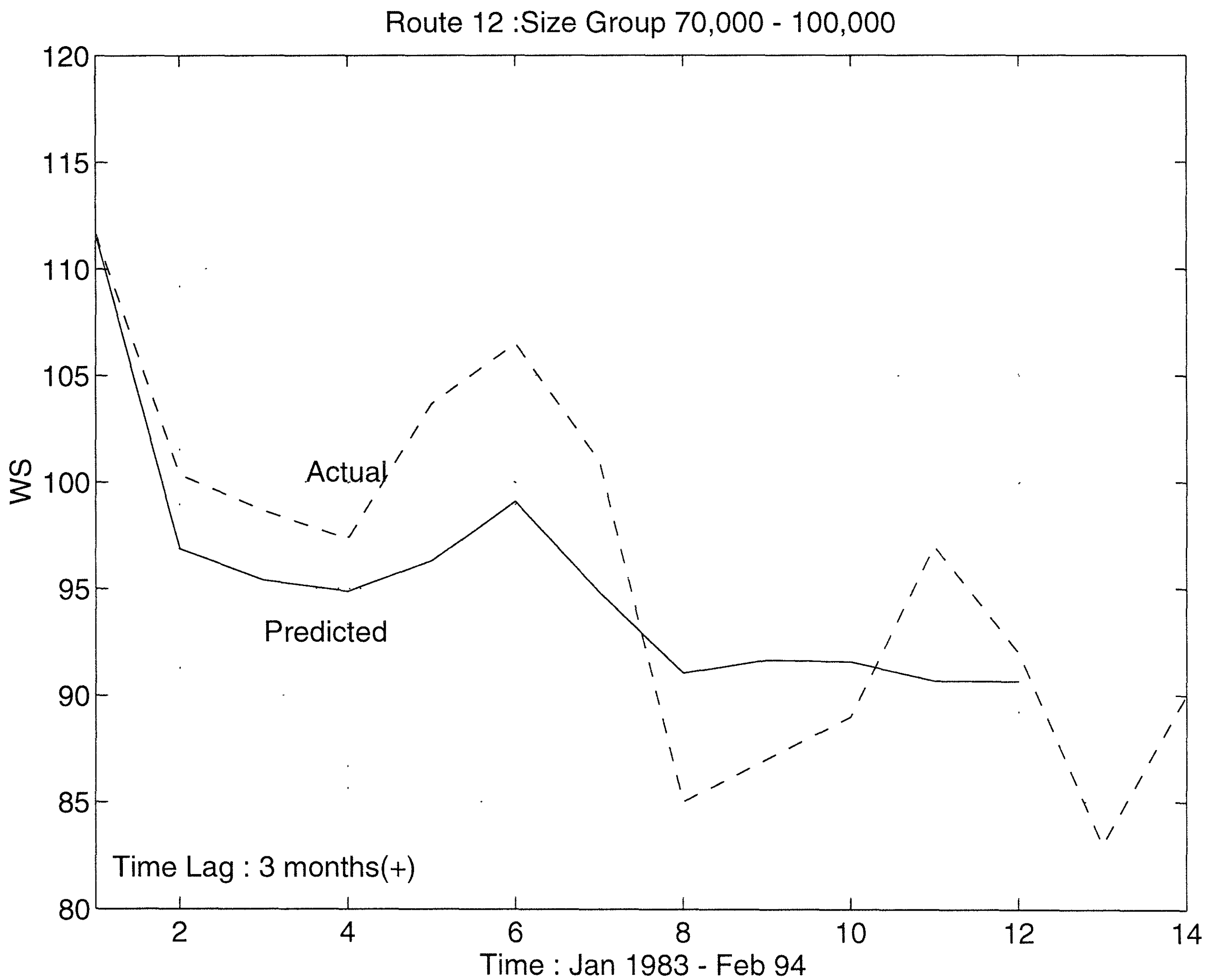


Figure 2-26: Freight Rates in Route MED-MED.

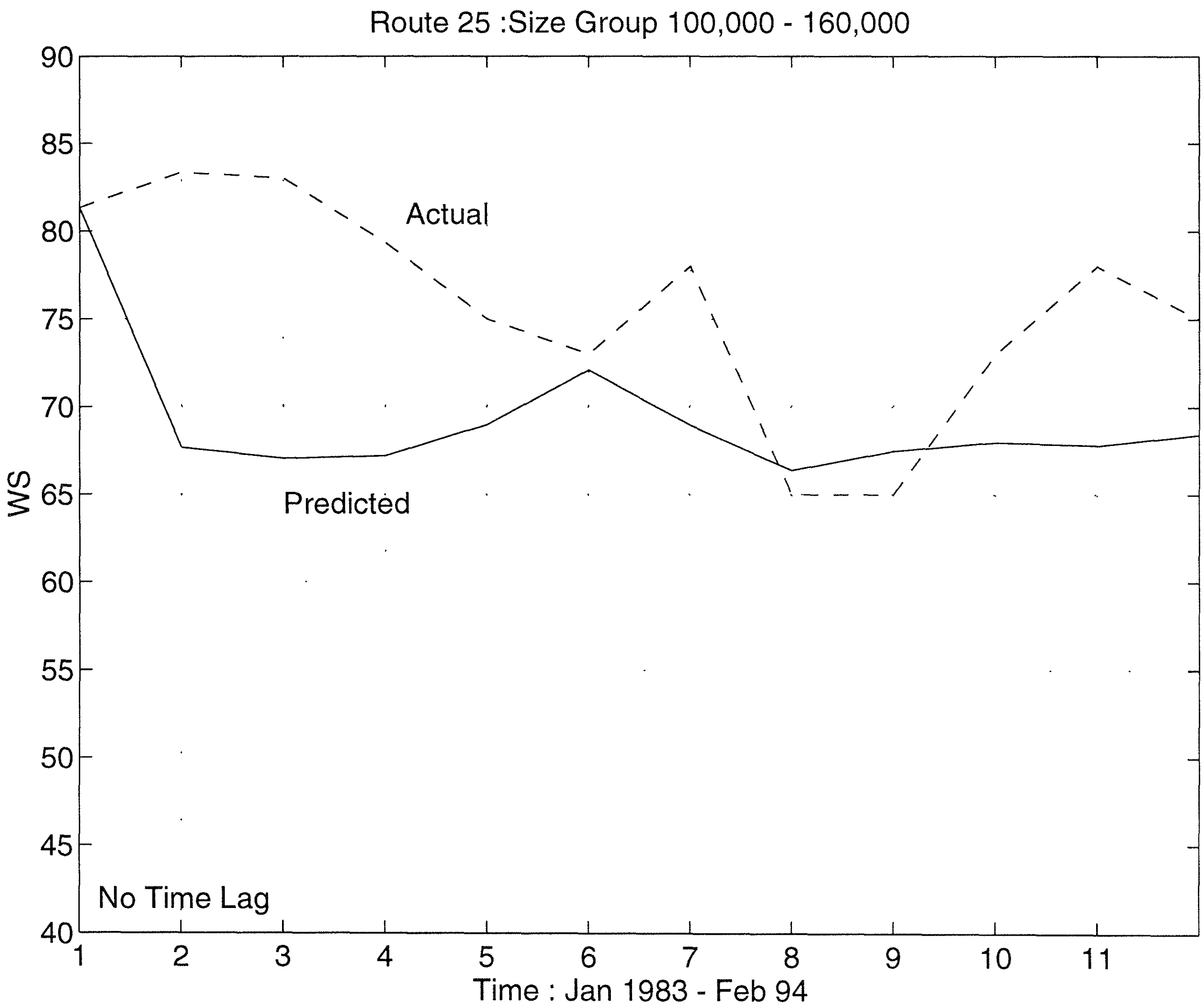


Figure 2-27: Freight Rates in Route WA-EUR.

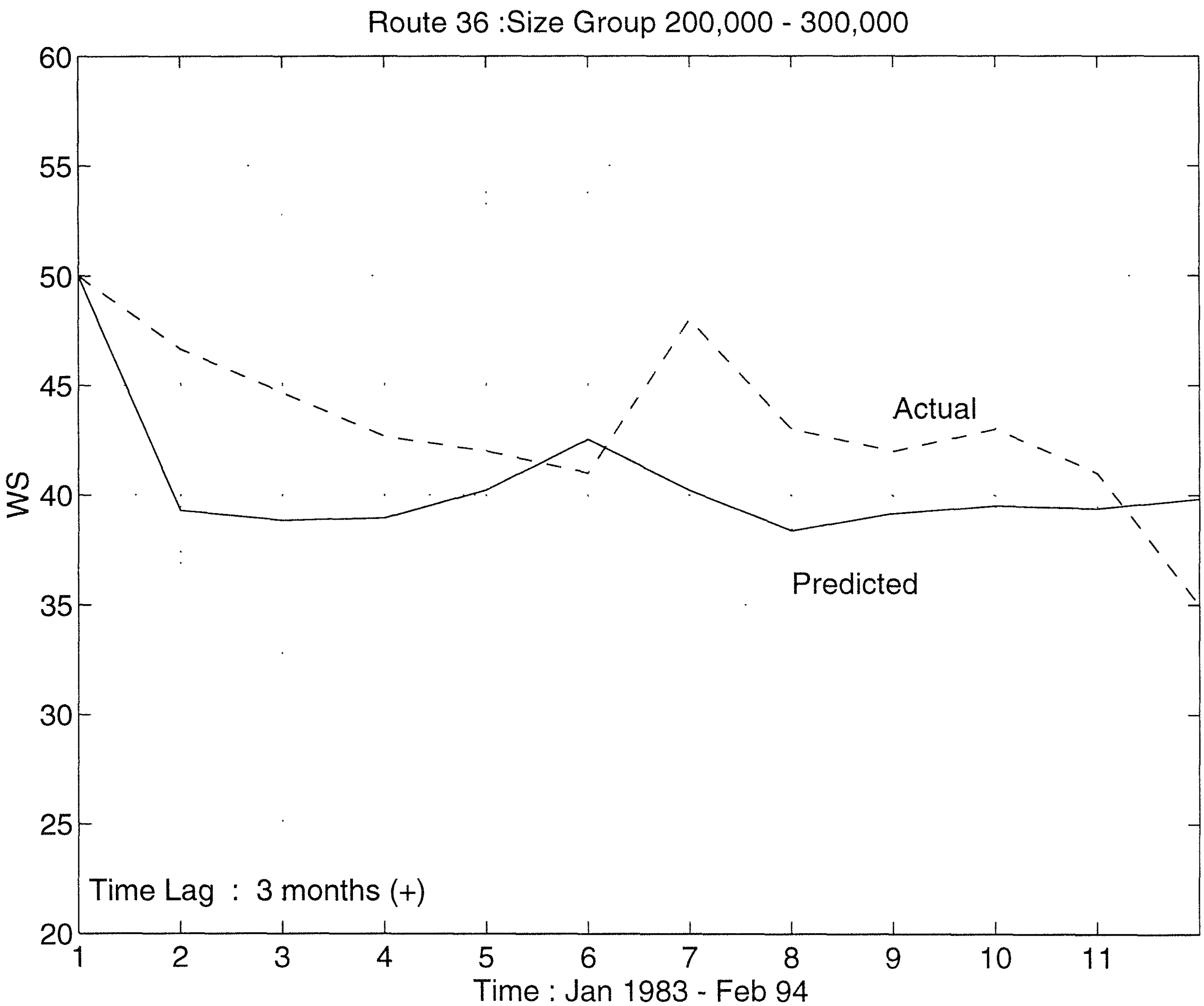


Figure 2-28: Freight Rates in Route AG-EUR.

2.5 Forecasting Freight Rates.

Combining the previous formulas that forecast supply and demand and thus deriving fleet inactivity by per size group, we were able to predict the expected freight rates. Prediction of the freight rates that will prevail in the trade routes that have been investigated, covers the period of the next two years (Jan. 1994 - Dec. 1995).

As input parameters have been used :

1. Prevailing Freight rates in all routes at the beginning of the forecasted period.

2. Industrial Production (assumed) of the U.S.A. , Japan and O.E.C.D. for the next two years. Three different scenarios (best, medium, worst from the side of the shipowner) have been assumed. Estimations of future Industrial Production were based on data given in [9].

3. Orders in shipyards to be delivered. As it takes two years in average for a ship to be delivered, we know the ships that will join the world fleet for the period of interest (the following two years).

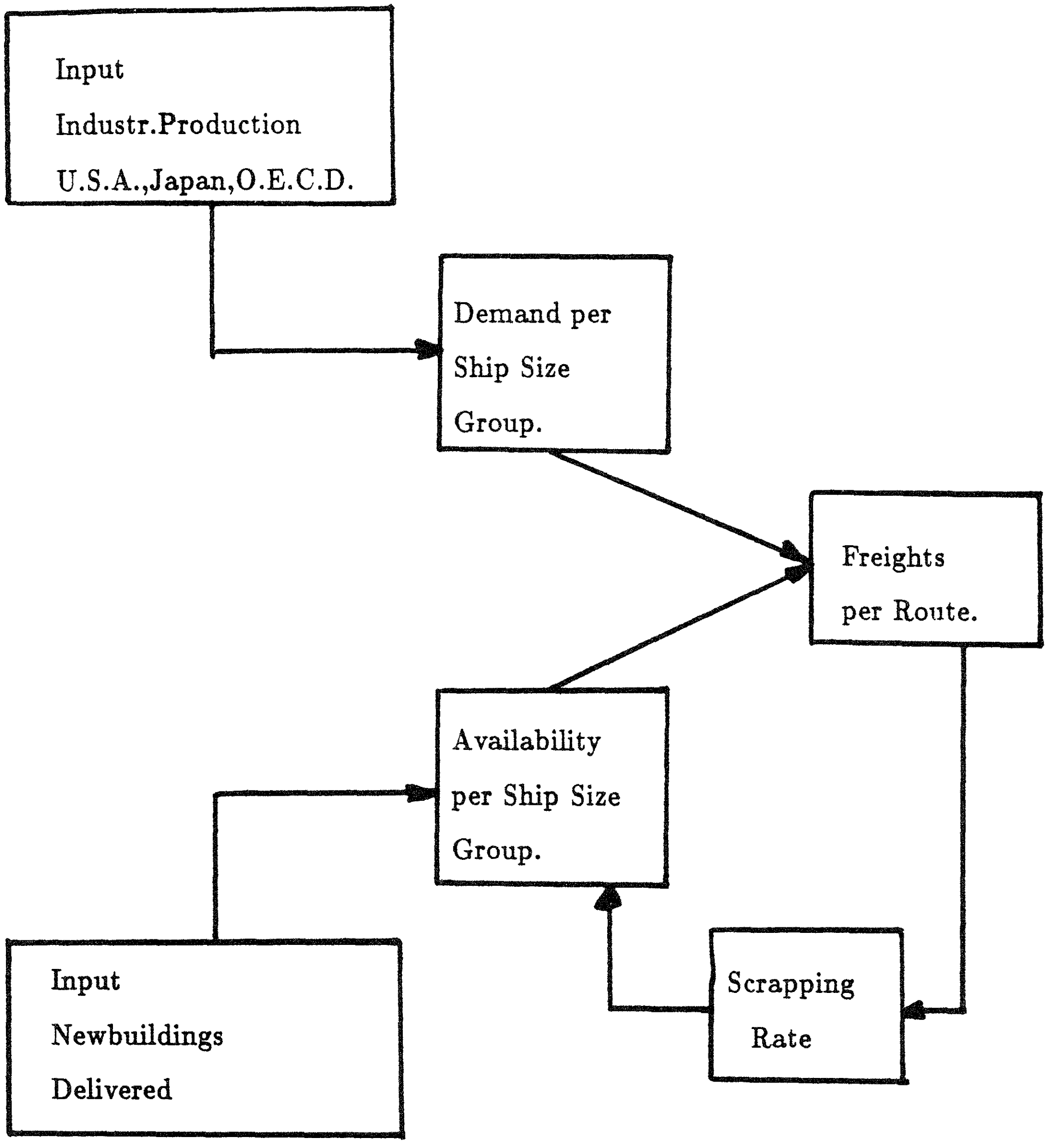
The structure of the program (see diagram) is as follows:

- Step 1: Forecasting demand transportation capacity: From the industrial production of the industrialized countries (U.S.A., Japan , O.E.C.D.) we may predict the total demanded transportation capacity per ship size group for the concerning period.

- Step 2: Forecasting available transportation capacity: From the freight rates in month (i-1) we may define scrapped tonnage (for each size group) for the next month (i). Also, as deliveries of newbuildings are given, we may define the available capacity for each size group in month (i).

- Step 3: Forecasting freight rates: Comparing the available and demanded transportation capacity for each size group, we may derive the expected idleness rate for each size goup and therefore the prevailing freight rates on the concerning trade routes in month (i). (Go to step 2)

We may notice the high sensitivity of the forecasted freights on the asssumed industrial production.



Results are shown in the folllowing figures:

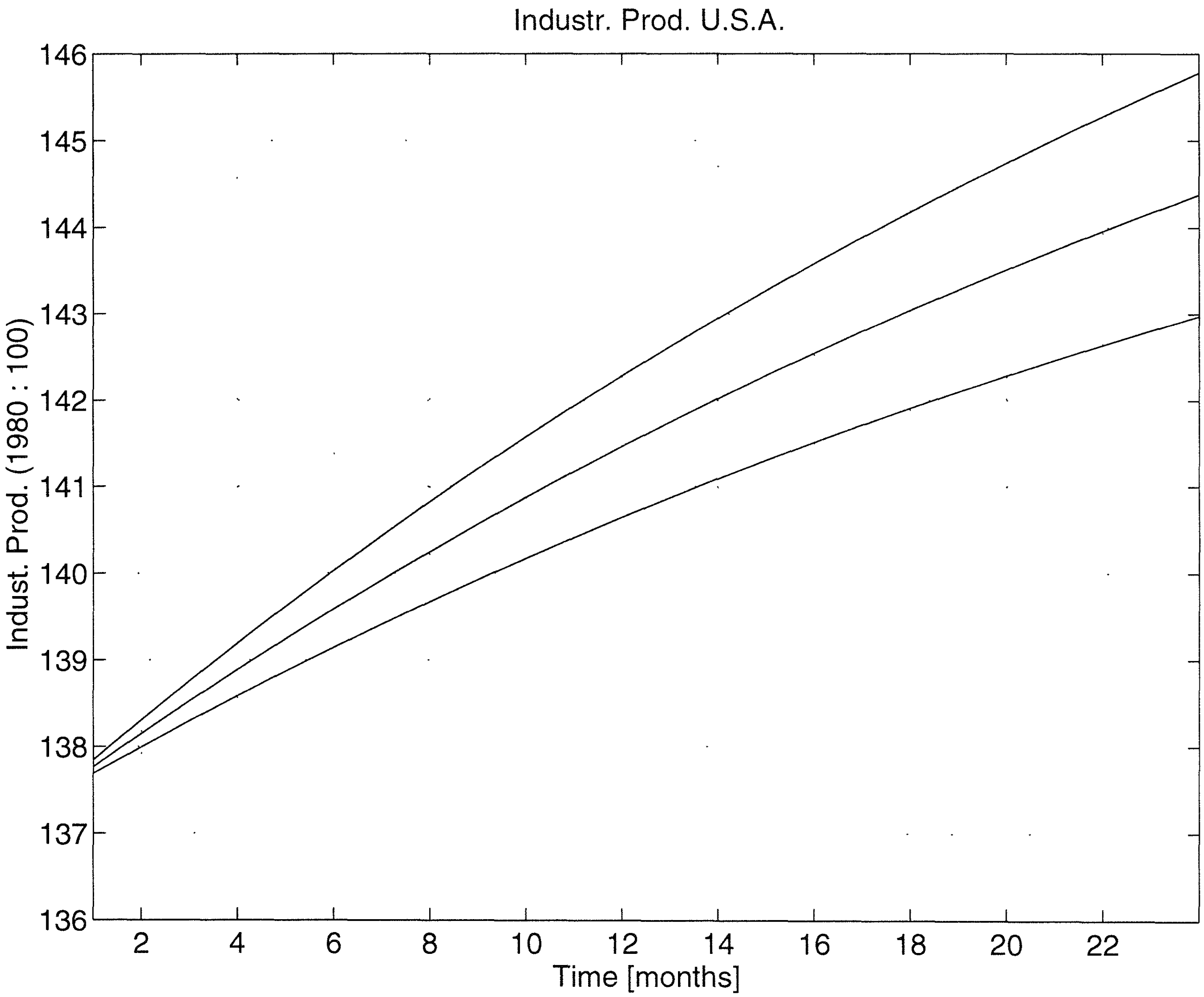


Figure 2-29: Industrial Prod. U.S.A.

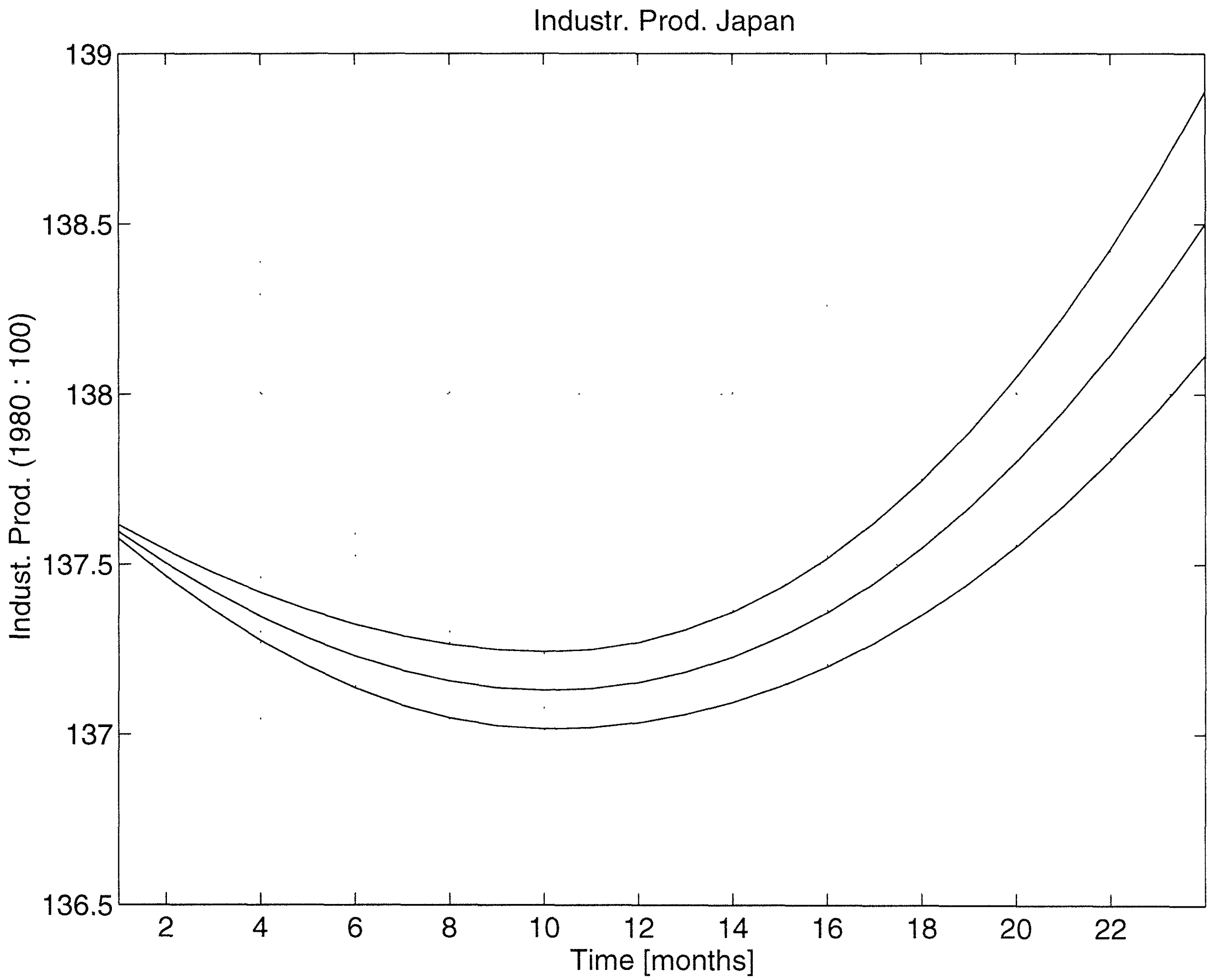


Figure 2-30: Industrial Prod. Japan

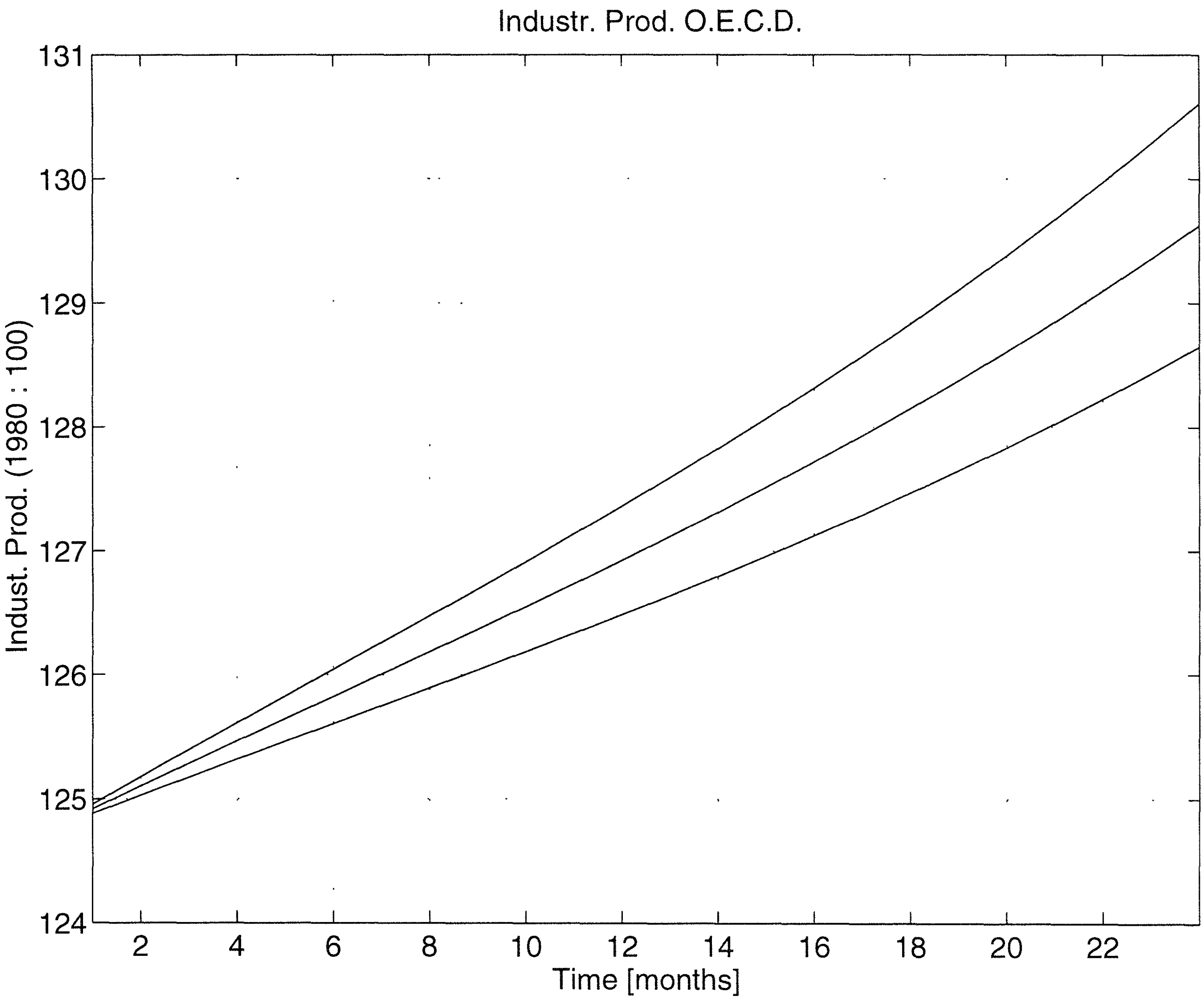


Figure 2-31: Industrial Prod. O.E.C.D.

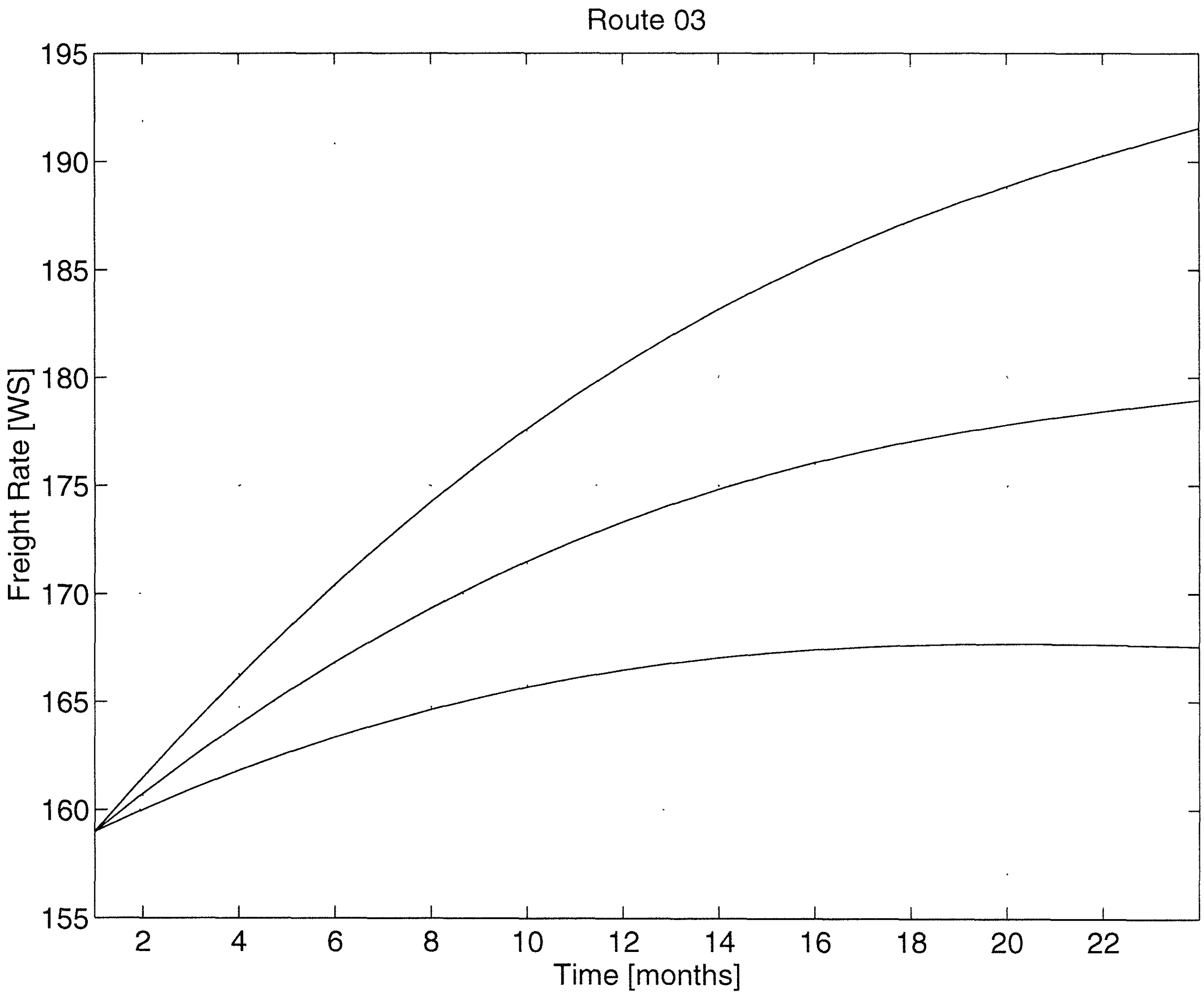


Figure 2-32: Forecasted Rates in Route : Carribean - U.S.E.S.

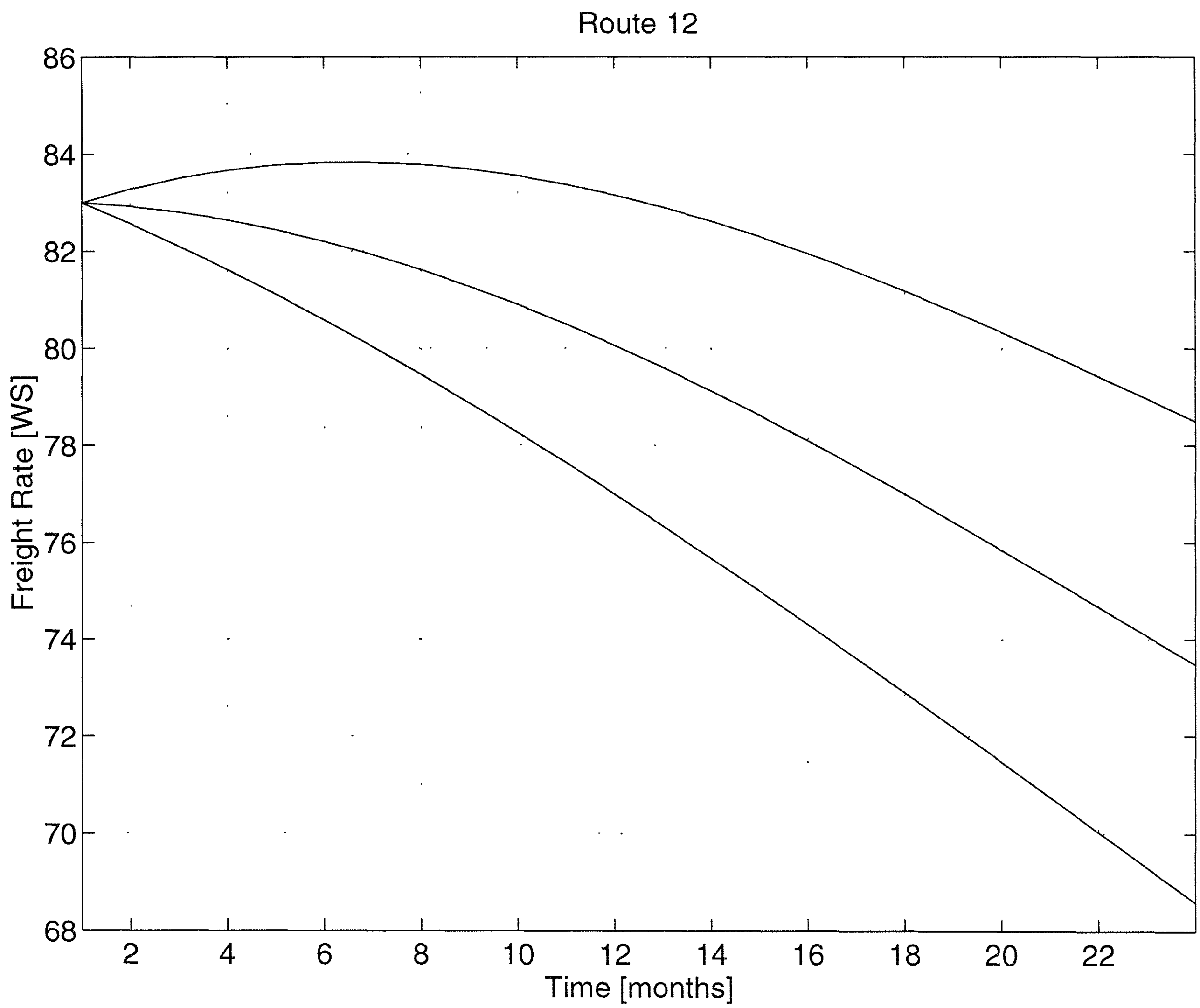


Figure 2-33: Forecasted Rates in Route : Medit. - Medit.

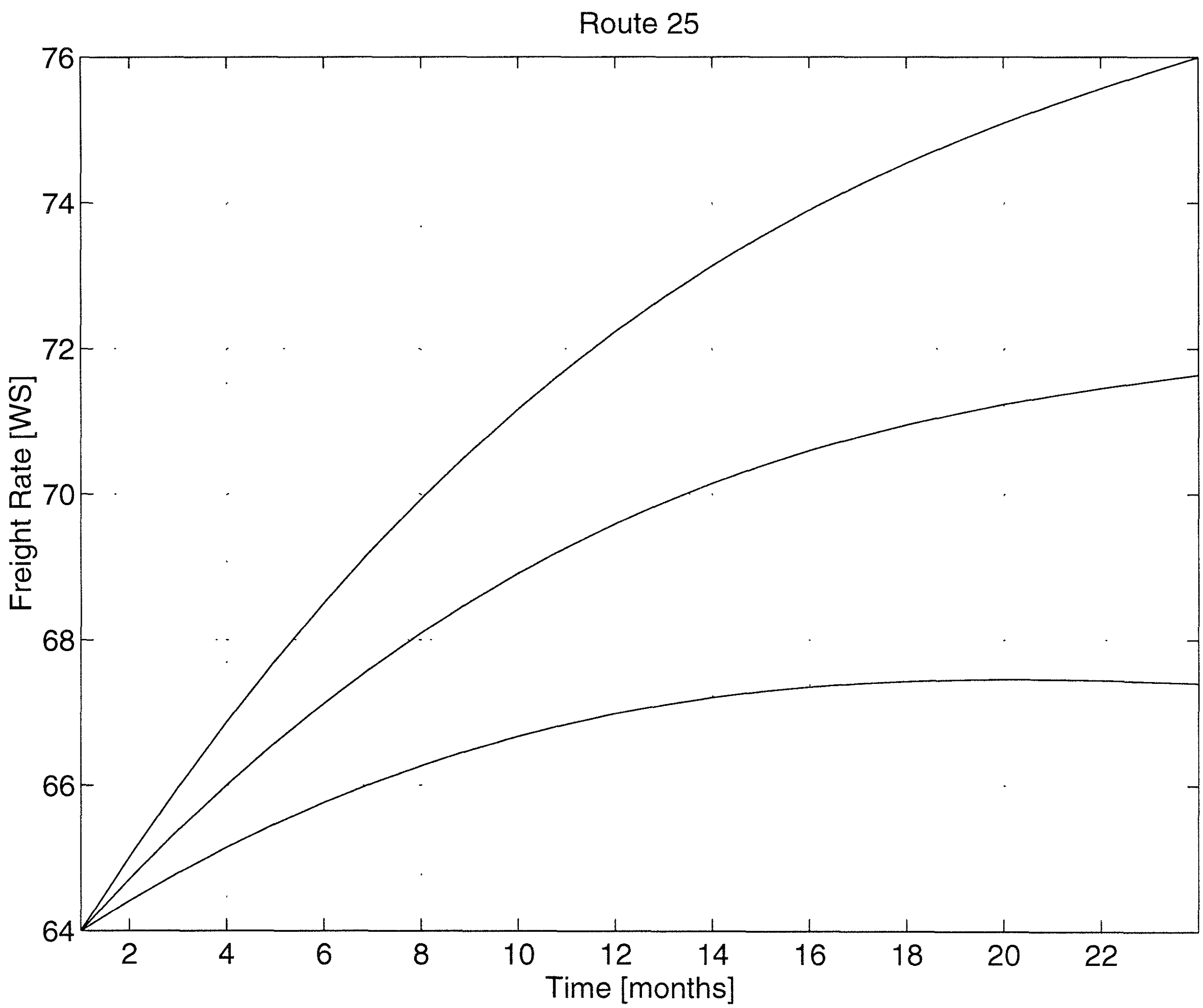


Figure 2-34: Forecasted Rates in Route : West Afr. - Europe

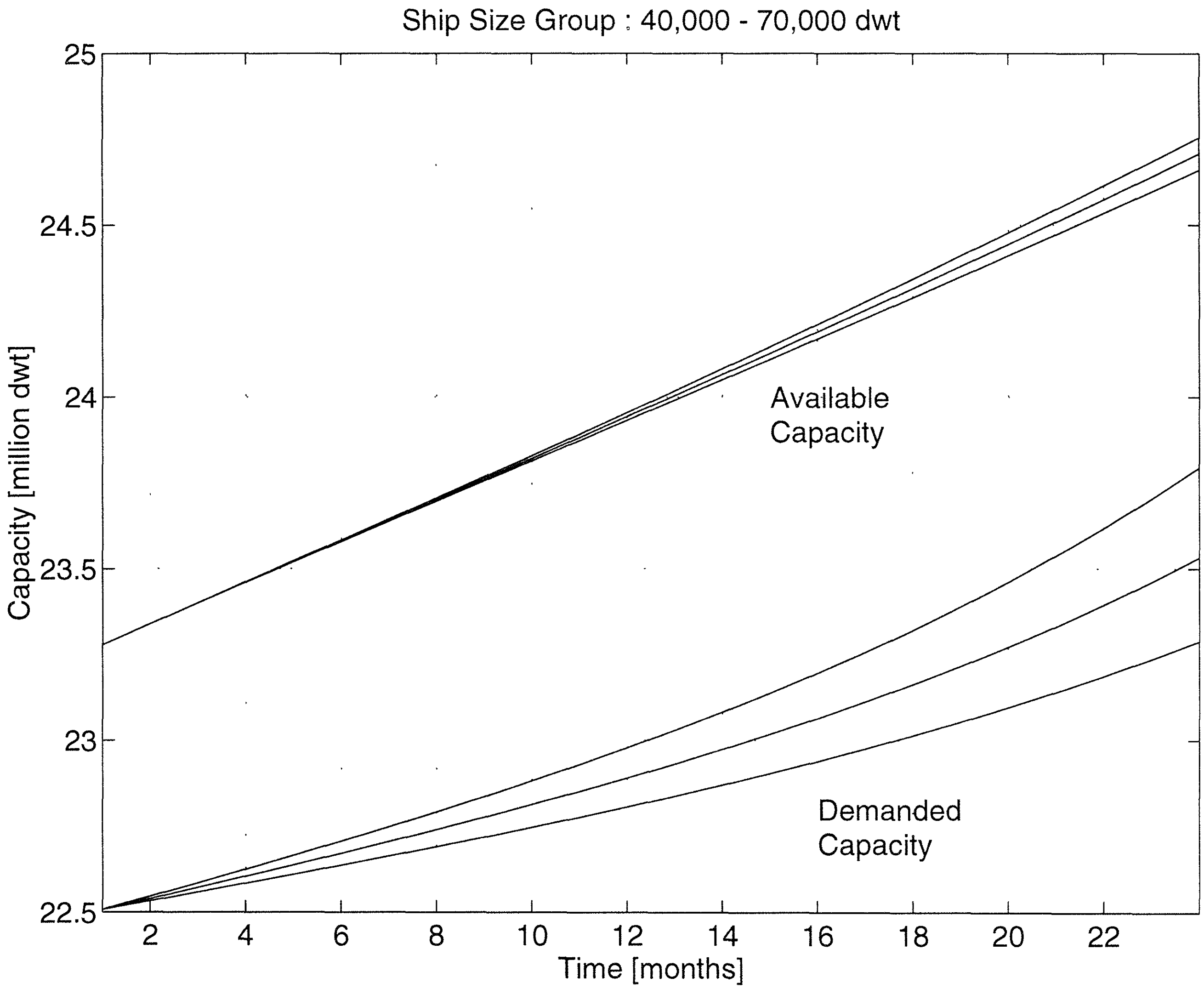


Figure 2-35: Forecasted Available - Demanded Capacity

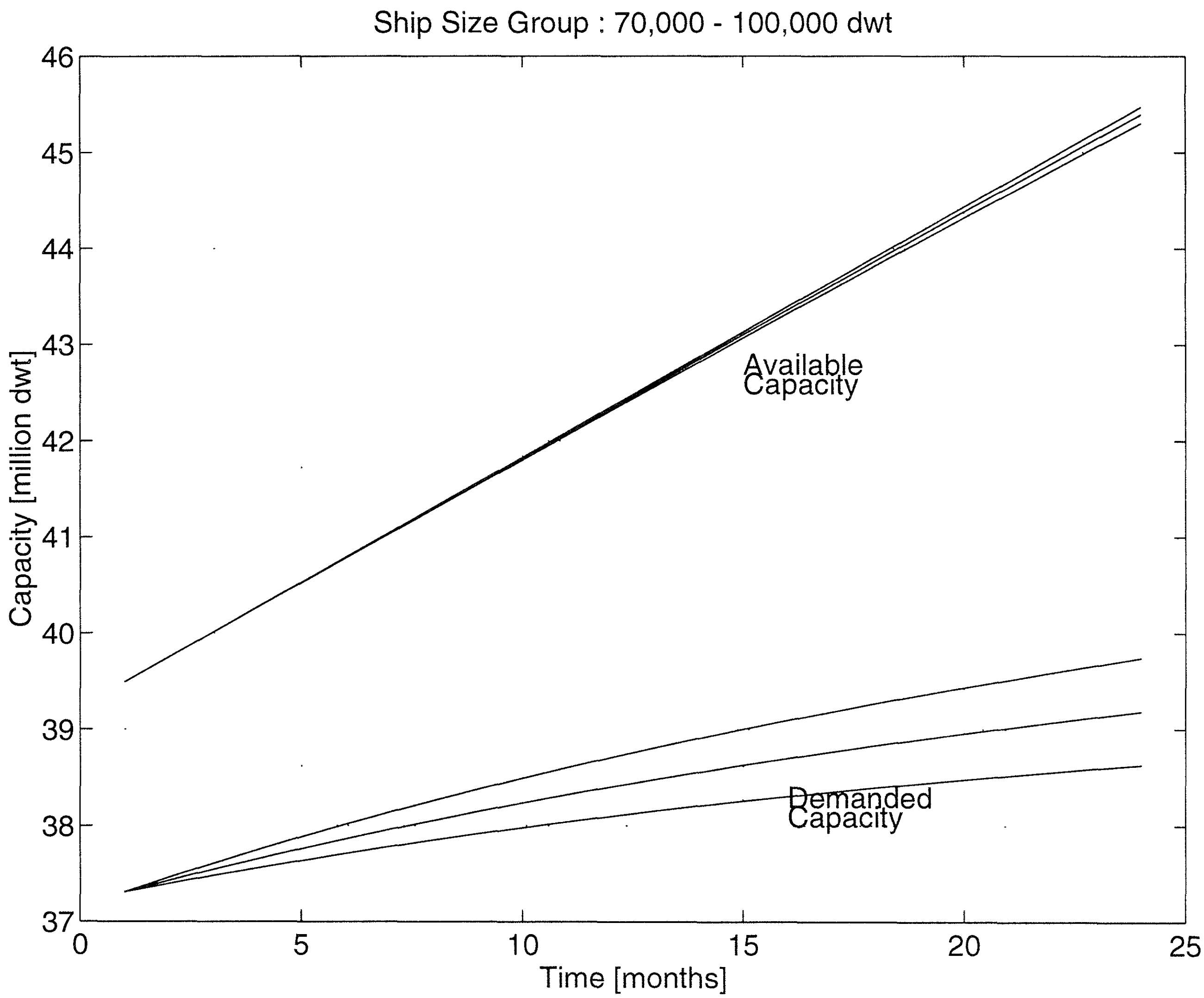


Figure 2-36: Forecasted Available - Demanded Capacity

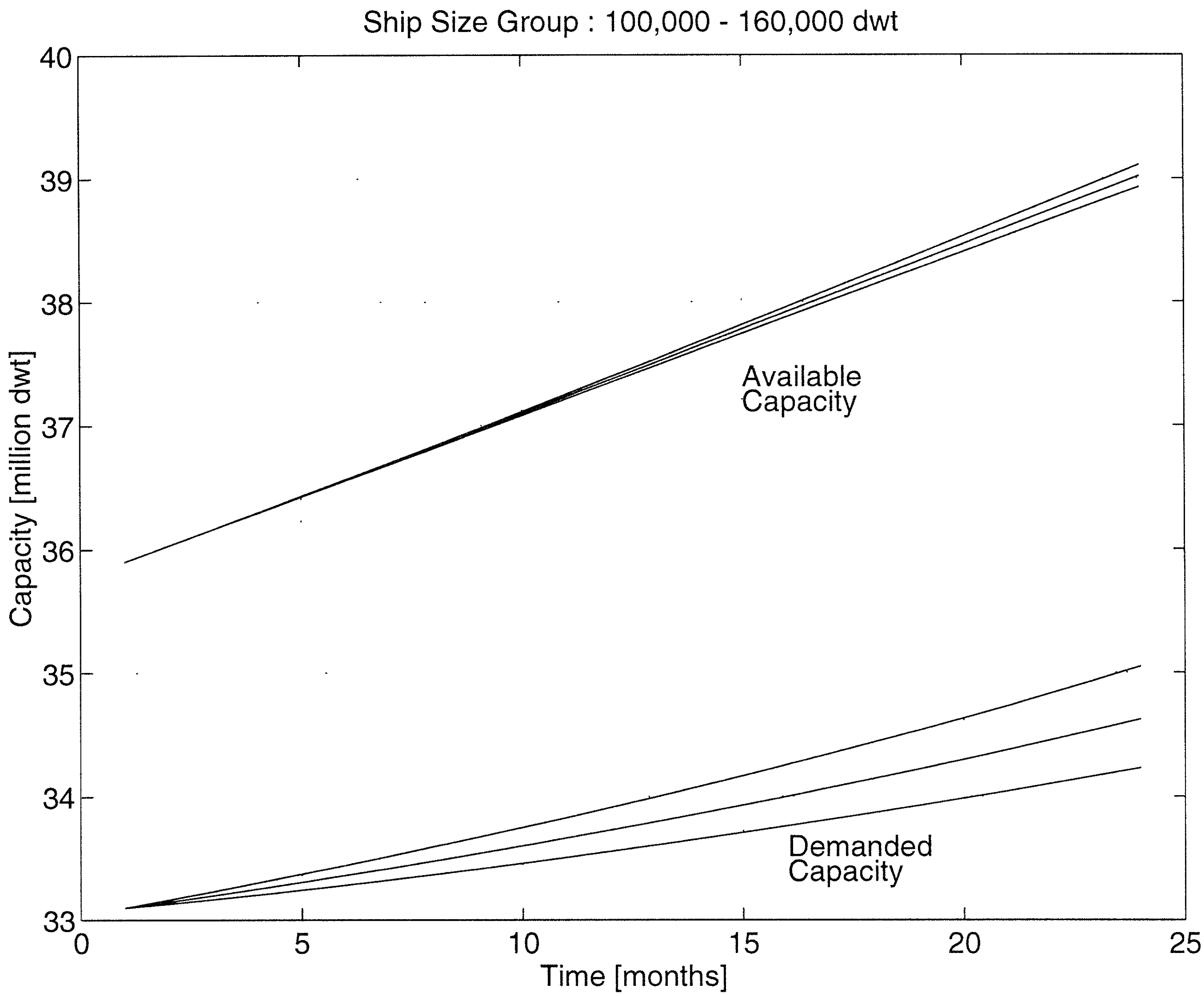


Figure 2-37: Forecasted Available - Demanded Capacity

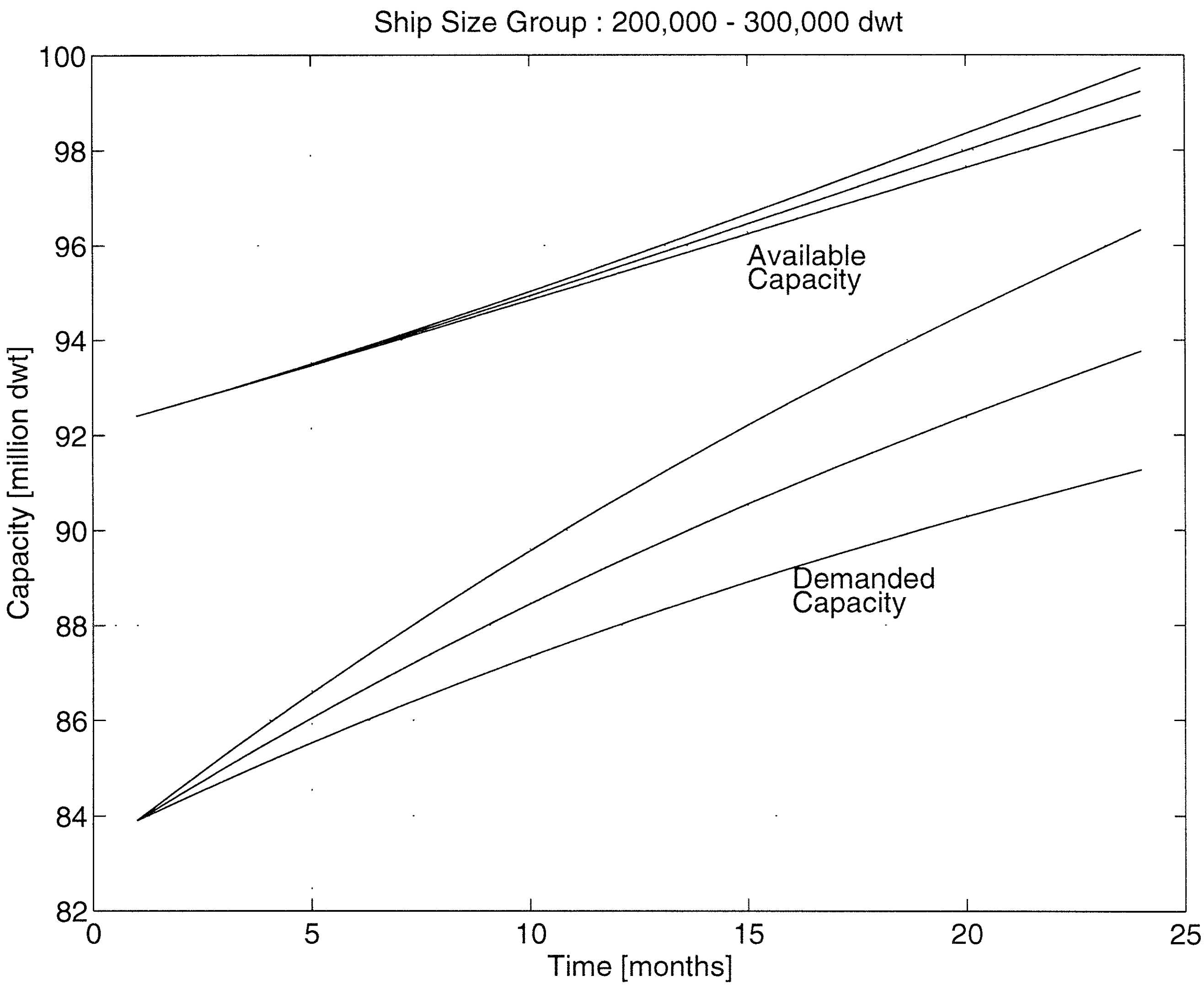


Figure 2-38: Forecasted Available - Demanded Capacity

2.6 Towards a better prediction model

Although the model gives a good estimation of future freight trends, further development may be accomplished, considering the following:

1. The period from which data was gathered, shows stable (and very low) oil prices. Actually oil prices reached their lowest levels since W.W.II (in real terms). Therefore, no correlation is expected between tanker freight rates and oil prices. On the other hand, it is obvious that an increase in oil prices would affect freight rates in more than one way:

   - Increase of vessel's operation costs.
   - Consuming countries, afraid of further rise in oil prices will try to increase their oil reserves. As every one will rush to buy oil at the same time, tanker freight rates will top up.

     It should be noted that this increased demand for oil transportation capacity will not be accompanied by proportional industrial production.
   - While oil prices remain high, industrial countries will move towards recession. In the same time, they wil try to find alternative ways to supply their industry (for example, coal). As a result, tanker demand will drop. Effects will be intensified due to the large reserves built up at the beginning of the cycle.

   We conclude therefore that not only oil prices should be considered, but their trend as well (change from previous months).

2. Combined cargo vessels, i.e. ships that can transport oil or dry cargo, should also be considered. When transportation rates in the tanker market are high and the dry cargo market is low, ships from the former market will move to the latter. If freights are in the same level in both markets, no movement of vessels from one market to the other should be expected.

   Therefore, rates in dry cargo market should also be included

3. Transported oil quantity is less due to hidden inactivity. During periods of low rates, ships will operate at lower speeds than their service speed (slow steaming) as a mean to cut their operational costs. Also ships tend to spend more time in ports

as shipowners use this low-chartering period doing repairs. Finally, more ships are unhired, but still are not included in the "idle" portion of the analysis, as their time in port is less than two months.

A way to calculate hidden inactivity due to slow steaming and excess port time, is to subtract the calculated travel length under normal speed (14.5 knots for almost all tankers) from the actual days of the voyage length. If we want inactivity in tons*miles we have to multiply ship's DWT by calculated days of hidden inactivity by 24 hours by ship's service speed. The same must be done for all ships. By the term, voyage, we mean round trip (date of departure from a discharge terminal to the date of departure from the next discharge terminal).

An example of slow steaming is the average speed observed in medium-size tankers was somewhat less than 12 knots (11.8 knots) although their designed service speed was higher.

Chapter 3

Conclusions

As stated in the introduction (Chapter 1), the object of this thesis was the explanation and prediction of the freight tanker rates. Linear regression theory was used as a mathematical tool for the analysis. The trade routes examined (24 in total) were different not only in the prevailing size of operating vessel but also in terms of port of departure and port of destination, thus giving a global perspective of the market.

The first issue addressed (Chapter 2) was the prediction of the tanker demand. Demand for oil transportation is a function of the oil neeeds of the consuming nations, the portion of oil that has to be transfered by sea, and the distance between producing and consuming areas. The explanatory variables used were the industrial production of four countries / group of countries : U.S.A., JAPAN, OECD and EUROPE. The explanatory power of GDP of U.S.A., JAPAN, U.K, and FRANCE (the last two being two typical representative countries from Europe) was also examined. The conclusions were the following:

1. Demand for small tankers (size : 40,000 - 70,000 DWT) is proportional to the industrial production of OECD.

2. For larger size groups (70,00 - 100,000 DWT, 100,000-160,000 DWT and 200,000 - 300,000 DWT) demand is proportional to the industrial production of U.S.A. and JAPAN.

3. The GDP has no explanatory power if industrial production is already included.

4. Finally, the industrial production of Europe can not be regarded as a variable inde-

pendent from the industrial production of U.S.A., Japan and OECD.

The second step in this investigation was the prediction of tanker availability. Knowing the number and size of tankers in the market at a specific time, we may predict availability in the future by adding newbuildings and subtracting scrapped ships. As it takes two years to build a ship from the time the order is placed, we are in position to know the time each ship will reach the market (assuming no delays). To predict the tonnage of scrapped ships, the explanatory variables used were the condition of the market (prevailing freight rates) for the same ship size and the portion of the "aged " fleet. The conclusions were:

1. Prevailing freight rates (for similar size ships) give a good estimation of the capacity to be scrapped for small and medium-size tankers and a mediocre one for VLCC's and ULCC's.

2. If we consider the "aged" portion of the fleet, we see that it correlates only for medium and large size tankers. The age at which a ship starts to be considered "old" is 17 years for medium and 14 years for large tankers.

The third step was the derivation of a relation predicting tanker freight rates considering tanker availability and tanker demand. The idle portion of the fleet may be calculated from the tanker availabilty and demand. Freight rates were then expressed as a function of the idleness. The conclusions were that for trade routes where ships of a certain size do not affront competition from larger (or smaller) ones, [1] freight ates behavior was the same. Same behavior in rates was also noticed between similar size ships serving trade routes with competition from larger (or smaller) size ships.

As a final step of the development of my model, all the equations derived from the above analysis were integrated in a tanker's freight rate forecast program. Testing the code for validity, the period from June 1993 to May 1994 was examined. The predicted results were consistent with the actual ones.

Finally, in Chapter 3, I derived the future behavior of the tanker market for the period June 1994 - May 1996, assuming three different scenarios for the industrial production (and the consecutive demand in oil) of the industrialized countries. The market shows

[1]As stated in Chapter 1, larger ships may not be competent to serve in a trade route, due to draft limitations of ports - canals and due to small distances to be travelled . Increased ratio of days in port over total round trip duration makes larger ships unfavorable, despite the economy of scale they pesent.

to be in equilibrium, and no excess in supply or demand of transportation capacity is expected under the scenarios assumed.

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Appendix A

Loading Zones - Draft[2]

1) West Africa[1]

Country	Port	Draft (ft)
Zaire	BANANA	35
Congo	DENJO	53
Gabon	GAMBA	44
Congo	POINTE NOIRE	34
Angola	QUINFUQUENA	46
Gabon	PORT GENTIL	43
Togo	LOME	31
Nigeria	ESCRAVOS	no res.
Nigeria	BONNY	no res.
Nigeria	FORCADOS	no res.
Angola	CABINDA	no res.
Nigeria	LUCINA	no res.
Nigeria	PENNINGION	no res.
Gabon	CAP LOPEZ	no res.
Nigeria	BRASS	no res.
Nigeria	QUAI-BOE	no res.

[1] "no res." stands for: No restriction in draft

2) Arabian Gulf

Country	Port	Draft (ft)
Abu Dhabi	JEBEL DHANA	45-49
Iran	LAVAN ISLAND	43
Kuwait	MINA SAUD	52/56
Sharrjah	HAMRIYAH	55
Qatar	UMM SAUD	43-60
Adu Dhabi	MUBARRAS ISLAND	45-54
Abu Dhabi	DAS ISLAND	50-79
Kuwait	MINA AL AHMADI	49/59/94/100
Saudi Arabia	RAS AL KHAFJI	47-64
Saudi Arabia	RAS TANURA	no res.
Iran	KHARG ISLAND	no res.
Dubai	FATEH TERMINAL	no res.
Oman	MINA AL FAHAL	no res.
Iran	SIRRI ISLAND	no res.
Qatar	HALUL ISLAND	no res.
Saudi Arabia	RAS AL KHAFJI	no res.
Abu Dhabi	ABU AL BU KHOOSH	no res.
Abu Dhabi	ZIRKU ISLAND	no res.
Sharjah	MUBAREK TERMINAL	no res.

3) S E Asia

Country	Port	Draft (ft)
Indonesia	DUMAI	54
Malaysia	MIRI	no res.
Brunei	SERIA	no res.

4) North Africa

Country	Port	Draft (ft)
Libya	TOBRUK	46
Algeria	ARZEW	49
Libya	MARSA EL BREGA	35
Libya	ES SIDER	no res.
Libya	ZUEITINA	no res.
Libya	RAS LANUF	no res.

5) Carribean

Country	Port	Draft (ft)
Mexico	COATZALCOALCOS	29
Mexico	CAYOS ARCOS TERMINAL	
St. Lucia	CUL DE SAC	
Venezuela	PUERTO MIRANDA	36
Venezuela	LA SALINA	39
Mexico	DOS BOCAS	
Trinidad	GALEOTA MPOINT	no res.
N.Antilles	BONAIRE	no res.
N.Antilles	BULLEN DAY	no res.

6) North Europe

Country	Port	Draft (ft)
United Kingdom	SULLOM VOE	42
United Kingdom	TEES	55
United Kingdom	HOUND POINT	no res.
United Kingdom	SCAPA FLOW	no res.
Netherlands	EUROPOORT	no res.
France	LE HAVRE	no res.

7a) Eastern Mediterranean

Country	Port	Draft (ft)
Turkey	CEYHAN TERMINAL	37
Lebanon	TRIPOLI	56
Turkey	ISKENDERU~~M~~N	30
Syria	TARTOUS	33
Egypt	SIDI KERIR	no res.

7b)Iraq pipelines

Country	Port	Draft (ft)
Syria	BANIAS	no res.
Lebanon	TRIPOLI	no res.

8) Red Sea

Country	Port	Draft (ft)
Egypt	RAS SHUKHEIR	55
Sudan	PORT SUDAN	37
Saudi Arabia	YENBU	no res.
Egypt	WADI FEIRAN	no res.

Appendix B

Discharge Zones - Drafts[2]

1)South Europe

Country	Port	Draft (ft)
Italy	TRIESTE	54
Italy	LEGHORN	34/37
Italy	SARROCH	58
Italy	VENICE	29/31
Italy	SAVONNA	30/34
Italy	LA SPEZIA	40
Spain	MALAGA	32
Spain	HUELVA	28/40
Italy	GENOA	48/57
Italy	AUGUSTA	no.res
France	FOS	no.res
Italy	TARANTO	no.res
Italy	MELLILI	no.res

2) North Europe

Country	Port	Draft (ft)
Netherlands	ROTTERDAM	36
West Germany	BRUNSBUTTEL	26/34
United Kingdom	IMMINGHAM	34/49
France	DUNKIRK	47
Denmark	GULFHAVN	49
Denmark	TETNEY TERMINAL	60
France	DONGES	47
Sweden	GOTHENBURG	43/64
Sweden	BROFJORDEN	26/42/82
Netherlands	EUROPOORT	no.res
United Kingdom	MILFORD HAVEN	no.res
Germany	WILHELMSHAVEN	no.res
France	LE HAVRE	no.res
Norway	MONGSTAD	no.res

3) United States Eastern Seaboard

Country	Port	Draft (ft)
U.S.A.	PHILADELPHIA	55
U.S.A.	NEW ORLEANS	40
U.S.A.	GALVESTON	40
U.S.A.	BEAUMONT	38
U.S.A.	NEW YORK	36/38
U.S.A.	CORPUS CHRITI	39/45
U.S.A.	PORT ARTHUR	40
U.S.A.	FREEPORT (TEXAS)	36
U.S.A.	HOUSTON	39
U.S.A.	LOOP TERMINAL	110

4) East Coast South America

Country	Port	Draft (ft)
Brazil	RIO DE JANEIRO	52
Brazil	AREIA BRANCA	
Brazil	TRAMANDAI	52/89
Brazil	ANGRA DOS REIS	no.res
Brazil	SAO SEBASTIAO	no.res

5) Japan

Country	Port	Draft (ft)
Japan	SAKAIDE	30
Japan	SAKAI	51
Japan	MIZUSHIMA	49
Japan	YOKOHAMA	55/64
Japan	KIIRE	56/89/108
Japan	CHIBA	28/42/52/67
Japan	KASHIMA	no.res
Japan	OKINAWA	no.res

6) South East Asia

Country	Port	Draft (ft)
Philippines	BATANGAS	39
Thailand	SRIRACHA	50
Thailand	BANGKOK	35/47
Hong Kong	HONG KONG	42
Singapore	SINGAPORE ROADS	28/33/38/73
Singapore	PULAU BUKOM	

7) Caribbean

Country	Port	Draft (ft)
Virgin Is.	HOVIC	60
Bahamas	FREEPORT	40/47/50/51/82/83
Trinidad	POINT A PIERRE	22/33/35/37/74
N.Antilles	SAN NICHOLAS BAY	no.res
N.Antilles	BULLEN BAY	no.res
N.Antilles	BONAIRE	no.res
Bahamas	SOUTH RIDING POINT	no.res

8) West Coast United States

Country	Port	Draft (ft)
U.S.A.	LOS ANGELES	31/51
U.S.A.	SAN FRANCISCO	35
U.S.A.	PORT ANGELES	45
U.S.A.	FERNDALE	40
U.S.A.	EL SEGUNDO	56

Appendix C

Industrial Production Index[10]

Month No.	U.S.A.	Japan	Europe	O.E.C.D.
1	93.6000	101.5000	96.8000	95.5000
2	93.6000	100.7000	96.8000	95.5000
3	95.2000	102.9000	96.8000	96.3000
4	96.8000	102.9000	96.0000	97.1000
5	98.4000	102.9000	97.7000	98.0000
6	99.2000	103.7000	97.7000	98.7000
7	101.8000	103.9000	97.7000	99.9000
8	103.3000	106.6000	97.0000	100.4000
9	104.8000	108.5000	97.8000	101.7000
10	105.4000	107.2000	97.7000	101.7000
11	105.6000	109.4000	99.5000	103.0000
12	106.3000	110.4000	99.2000	103.1000
13	107.8000	110.6000	101.3000	104.9000
14	108.8000	114.5000	100.5000	105.3000
15	109.4000	112.8000	100.0000	105.1000
16	110.3000	113.4000	98.4000	104.7000
17	110.7000	116.1000	100.4000	106.3000
18	111.8000	116.7000	97.0000	105.1000
19	112.9000	117.2000	100.8000	107.4000
20	113.0000	118.1000	101.0000	107.7000
21	112.2000	116.7000	101.6000	107.5000
22	111.8000	120.2000	101.7000	107.9000
23	112.1000	120.6000	101.9000	108.1000
24	112.1000	120.0000	101.4000	107.9000
25	112.3000	120.3000	101.1000	107.9000

Month No.	U.S.A.	Japan	Europe	O.E.C.D.
26	113.9000	120.1000	102.4000	108.5000
27	114.2000	118.4000	103.8000	109.5000
28	114.3000	121.5000	102.4000	109.3000
29	114.3000	124.6000	103.2000	110.2000
30	114.5000	122.0000	104.2000	110.4000
31	114.3000	124.3000	104.9000	111.1000
32	115.3000	122.8000	104.2000	110.8000
33	115.2000	121.6000	104.6000	110.8000
34	114.5000	122.5000	105.5000	111.2000
35	115.5000	121.3000	106.9000	112.0000
36	116.4000	121.6000	102.9000	110.5000
37	116.7000	121.6000	104.5000	111.4000
38	115.7000	122.1000	105.5000	111.5000
39	113.8000	121.5000	105.4000	110.7000
40	114.8000	121.6000	107.1000	112.0000
41	114.4000	122.0000	103.9000	110.3000
42	114.4000	122.2000	106.8000	111.7000
43	115.0000	121.9000	107.6000	112.3000
44	115.2000	118.8000	106.4000	111.3000
45	115.0000	123.0000	106.8000	112.0000
46	115.4000	120.7000	107.3000	112.2000
47	116.0000	119.3000	107.0000	112.0000
48	116.7000	122.8000	106.0000	112.4000
49	116.5000	122.4000	105.0000	111.7000
50	117.1000	121.6000	107.2000	113.3000

Month No.	U.S.A.	Japan	Europe	O.E.C.D.
51	117.2000	123.7000	107.7000	113.9000
52	117.3000	122.0000	107.8000	113.6000
53	118.0000	120.6000	109.2000	114.5000
54	118.9000	125.3000	108.5000	115.3000
55	120.3000	126.7000	108.6000	116.0000
56	120.8000	125.3000	108.4000	115.5000
57	120.6000	124.6000	109.1000	115.7000
58	122.0000	126.8000	110.1000	117.0000
59	122.7000	127.1000	110.4000	117.5000
60	123.3000	128.6000	109.7000	117.6000
61	123.8000	129.1000	111.2000	118.4000
62	123.8000	132.6000	110.3000	118.6000
63	124.0000	132.9000	111.4000	119.3000
64	124.7000	131.9000	111.7000	119.4000
65	125.3000	128.8000	111.6000	119.2000
66	125.7000	133.1000	113.3000	120.9000
67	127.2000	131.4000	113.7000	121.3000
68	127.3000	135.1000	113.1000	121.8000
69	127.7000	135.8000	114.7000	122.8000
70	128.2000	135.6000	114.1000	122.2000
71	127.6000	139.0000	115.3000	123.3000
72	127.8000	139.3000	115.7000	123.6000
73	128.3000	140.2000	116.0000	123.9000
74	128.1000	138.1000	115.4000	123.4000
75	128.2000	144.3000	115.6000	124.5000

Month No.	U.S.A.	Japan	Europe	O.E.C.D.
76	129.0000	139.9000	117.5000	124.5000
77	129.0000	140.6000	114.4000	124.0000
78	129.3000	143.0000	117.4000	125.5000
79	129.2000	140.0000	118.4000	125.3000
80	129.7000	143.5000	118.4000	126.1000
81	129.1000	141.6000	117.7000	125.4000
82	128.6000	141.6000	118.5000	125.4000
83	129.0000	142.7000	119.0000	125.9000
84	129.5000	142.8000	119.6000	126.5000
85	128.4000	142.8000	119.3000	125.8000
86	129.4000	142.9000	118.4000	125.9000
87	129.9000	144.7000	119.7000	126.7000
88	129.8000	143.8000	118.6000	126.2000
89	130.4000	147.0000	119.1000	127.2000
90	131.1000	147.1000	120.2000	127.9000
91	131.4000	149.3000	120.2000	128.5000
92	131.4000	149.8000	120.6000	128.7000
93	131.6000	148.4000	120.6000	128.4000
94	130.6000	151.4000	119.8000	128.4000
95	129.2000	150.7000	119.0000	127.2000
96	128.1000	149.8000	119.2000	126.6000
97	127.4000	151.9000	120.4000	127.1000
98	126.5000	151.8000	120.5000	126.7000
99	125.7000	149.1000	118.6000	125.2000
100	126.3000	149.4000	118.3000	125.5000

Month No.	U.S.A.	Japan	Europe	O.E.C.D.
101	127.2000	152.2000	118.7000	126.4000
102	128.2000	148.9000	121.2000	127.3000
103	128.9000	152.8000	120.3000	127.9000
104	128.9000	148.9000	118.3000	126.4000
105	129.3000	149.5000	119.7000	127.3000
106	129.3000	150.0000	119.9000	127.4000
107	129.0000	149.9000	120.1000	127.3000
108	128.3000	148.0000	117.6000	125.6000
109	127.4000	147.5000	119.8000	126.1000
110	128.1000	146.6000	120.8000	126.6000
111	128.5000	143.1000	120.1000	125.9000
112	129.0000	143.5000	118.8000	125.7000
113	129.9000	141.4000	119.1000	125.9000
114	129.4000	144.0000	118.7000	125.8000
115	130.4000	144.9000	119.3000	126.6000
116	130.1000	140.2000	117.8000	125.1000
117	129.9000	145.7000	118.0000	126.1000
118	130.7000	142.4000	118.2000	126.0000
119	131.3000	140.1000	116.2000	125.0000
120	131.6000	139.0000	115.2000	124.4000
121	132.0120	138.2895	113.6666	124.0740
122	132.6960	138.8820	115.0173	125.1720
123	132.9240	142.5555	114.9134	125.8308
124	133.2660	138.7635	112.9393	124.5132
125	133.0380	135.4455	114.8095	124.7328
126	133.4940	137.6970	113.6666	124.7328

Appendix D

Gross National Product Index.[9]

Month No.	France	Japan	U.K.	U.S.A.
1	100.0000	100.0000	100.0000	100.0000
2	100.6000	104.4000	106.0000	111.8000
3	99.4000	110.6000	109.2000	119.4000
4	101.8000	113.7000	111.7000	127.9000
5	104.6000	121.1000	115.2000	137.6000
6	102.0000	127.8000	111.5000	145.2000
7	106.0000	132.3000	112.3000	146.9000
8	108.8000	141.8000	118.5000	151.2000
9	108.5000	142.2000	121.5000	151.9000
10	112.0000	150.1000	126.4000	153.9000
11	114.4000	152.7000	128.2000	158.2000
12	116.8000	159.9000	130.4000	158.9000
13	118.0000	157.9000	131.8000	162.6000
14	122.5000	161.5000	132.5000	163.2000
15	123.3000	163.9000	136.4000	165.6000
16	124.9000	167.1000	139.2000	166.7000
17	125.7000	170.1000	140.9000	171.0000
18	128.9000	170.1000	143.0000	173.3000
19	133.3000	178.5000	151.8000	177.1000
20	134.9000	185.5000	155.8000	181.6000
21	139.8000	196.8000	158.5000	185.2000
22	142.2000	192.9000	160.3000	188.2000
23	145.3000	202.0000	165.1000	190.7000
24	147.3000	205.0000	167.3000	192.7000
25	152.1000	214.1000	168.7000	197.1000

Month No.	France	Japan	U.K.	U.S.A.
26	155.3000	211.0000	167.3000	198.8000
27	157.7000	223.2000	169.4000	201.8000
28	162.2000	226.2000	171.8000	202.7000
29	165.0000	236.6000	174.6000	204.8000
30	165.4000	240.2000	178.4000	206.0000
31	170.7000	244.3000	174.4000	207.7000
32	169.1000	246.4000	170.6000	205.7000
33	169.0000	257.6000	168.2000	203.1000
34	172.2000	259.6000	164.4000	203.0000
35	175.5000	261.2000	165.5000	204.7000
36	175.5000	261.3000	164.4000	205.5000
37	180.0000	264.7000	161.9000	207.9000
38	180.4000	265.4000	161.5000	209.3000
39	182.0000	263.9000	161.9000	212.7000
40	180.0000	263.6000	162.3000	217.5000

Appendix E

Total Transportation Capacity[10]

Month	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
1	5.4	10.5	14.8	4.4	9.1	8.6	8.95	17.0	9.2
2	5.4	10.6	14.9	4.35	9.0	8.5	8.9	17.2	9.2
3	5.4	10.6	14.9	4.35	8.85	8.5	8.9	17.2	9.2
4	5.5	10.6	14.9	4.2	8.6	8.6	8.8	17.0	9.0
5	5.5	10.6	14.8	4.4	8.5	8.5	8.5	17.0	8.8
6	5.4	10.6	14.8	4.3	8.5	8.55	8.4	16.9	9.1
7	5.4	10.6	14.8	4.4	8.5	8.4	8.4	17.0	9.1
8	5.4	10.5	14.7	4.3	8.6	8.5	8.3	17.2	8.8
9	5.4	10.4	14.8	4.3	8.5	8.4	8.1	17.2	8.8
10	5.4	10.4	14.8	4.35	8.5	8.3	8.0	17.15	8.8
11	5.3	10.3	14.8	4.3	8.4	8.2	7.8	17.0	8.7
12	5.3	10.3	14.8	4.3	8.4	8.1	7.8	17.0	8.7
13	5.1	10.0	14.7	3.9	8.1	9.5	6.1	17.9	8.8
14	5.1	10.0	14.8	3.9	8.2	9.4	6.1	17.8	8.8
15	5.1	10.0	14.9	3.9	8.2	9.3	6.1	17.7	8.8
16	5.1	10.0	14.9	3.9	8.2	9.3	6.1	17.8	8.8
17	5.2	10.4	15.1	3.9	8.0	9.3	6.1	17.6	8.9
18	5.1	10.3	15.0	3.9	8.0	9.3	6.1	17.6	8.9
19	5.0	10.1	14.9	3.8	8.0	9.2	6.1	17.5	8.8
20	5.0	10.0	14.9	3.8	8.0	9.2	5.9	17.4	8.6
21	4.9	9.7	14.9	4.0	7.9	9.4	5.7	17.5	8.7
22	5.0	9.7	14.8	3.9	7.9	9.4	5.7	17.4	8.6
23	5.0	9.7	14.9	3.9	7.8	9.7	5.7	17.1	8.5
24	4.9	9.6	14.8	3.9	7.8	9.9	5.6	17.1	8.7

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
25	9.5	5.0	7.1	10.1	6.0	9.4	9.3	17.1	8.7
26	9.4	5.0	7.1	10.2	6.0	9.3	9.3	17.0	8.7
27	9.5	5.2	7.1	10.5	6.1	9.2	9.4	16.9	8.6
28	9.5	5.2	7.1	10.3	6.1	9.3	9.4	16.8	8.5
29	9.5	5.3	6.8	10.0	6.2	8.9	9.6	16.7	8.4
30	9.4	5.3	6.8	10.0	6.2	8.8	9.7	16.7	8.3
31	9.3	5.3	6.8	10.1	6.2	8.7	9.7	16.6	8.1
32	9.3	5.4	6.9	10.1	6.1	8.7	9.7	16.6	8.1
33	9.2	5.4	6.9	10.1	6.2	8.6	9.4	16.5	8.0
34	9.1	5.3	6.9	10.1	6.1	8.6	9.4	16.5	7.9
35	9.1	5.3	6.9	10.1	6.1	8.5	9.4	16.7	7.9
36	9.0	5.3	6.8	10.2	6.1	8.5	9.3	16.8	7.9
37	9.0	5.4	6.6	10.0	6.1	8.3	8.9	17.1	7.7
38	8.9	5.4	6.5	10.1	6.2	8.3	8.9	17.0	7.6
39	8.9	5.5	6.4	10.1	6.2	8.3	8.9	17.1	7.6
40	8.9	5.5	6.5	10.1	6.1	8.4	9.0	17.1	7.6
41	9.1	5.6	6.7	10.6	6.0	8.4	9.0	17.2	7.6
42	9.1	5.6	6.7	10.6	6.0	8.4	9.0	17.4	7.6
43	9.1	5.6	6.8	10.5	5.7	8.4	9.0	17.5	7.6
44	9.1	5.6	6.8	10.6	5.6	8.4	9.1	17.5	7.6
45	9.1	5.7	6.7	10.4	5.8	8.3	8.9	17.6	7.7
46	9.1	5.7	6.7	10.5	5.7	8.3	8.9	17.6	7.8
47	9.1	5.7	6.7	10.5	5.6	8.3	9.0	17.7	7.9
48	9.1	5.7	6.6	10.5	5.6	8.3	9.0	17.7	8.0
49	9.1	5.8	6.6	10.4	5.6	8.3	9.0	17.9	8.0
50	9.1	5.8	6.7	10.4	5.4	8.1	9.1	17.8	7.9

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
51	9.1	5.8	6.6	10.4	5.4	8.2	9.2	18.0	7.9
52	9.2	5.8	6.7	10.5	5.4	8.2	9.3	18.1	7.9
53	9.1	5.8	6.7	10.5	5.4	8.3	9.3	18.2	7.9
54	9.1	5.8	6.7	10.5	5.4	8.3	9.3	18.0	7.9
55	9.1	5.8	6.7	10.3	5.6	8.0	9.6	18.0	8.2
56	9.1	5.8	6.6	10.3	5.5	8.1	9.6	18.0	8.2
57	9.1	5.7	6.6	10.2	5.7	8.1	9.3	18.4	8.2
58	9.1	5.7	6.6	10.2	5.7	8.2	9.3	18.5	8.2
59	9.1	5.7	6.6	10.2	5.8	8.1	9.3	18.4	8.2
60	9.1	5.6	6.6	10.3	5.8	8.1	9.2	18.6	8.3
61	9.1	5.7	6.6	10.4	5.7	8.1	9.2	18.8	8.3
62	9.1	5.6	6.6	10.4	5.7	8.1	9.2	18.8	8.3
63	9.1	5.6	6.6	10.5	5.7	8.1	9.2	18.9	8.3
64	9.1	5.7	6.6	10.7	5.7	8.1	9.4	19.0	8.3
65	8.9	5.6	6.6	10.7	5.6	8.1	9.3	19.0	8.2
66	8.9	5.6	6.6	10.6	5.6	8.3	9.4	18.9	8.2
67	8.8	5.7	6.6	10.8	5.4	8.4	9.2	19.4	7.8
68	8.8	5.7	6.6	10.9	5.4	8.4	9.2	19.6	7.8
69	8.8	5.7	6.6	10.9	5.4	8.3	9.2	19.4	7.7
70	8.8	5.7	6.6	10.9	5.2	8.3	9.3	19.4	7.7
71	8.8	5.8	6.6	11.1	5.3	8.4	9.3	19.4	7.7
72	8.8	5.8	6.6	11.1	5.4	8.4	9.3	19.6	7.7
73	8.8	5.8	6.6	11.2	5.4	8.4	9.3	19.6	7.7
74	8.8	5.8	6.6	11.3	5.4	8.4	9.3	19.6	7.7
75	8.8	5.8	6.6	11.3	5.4	8.4	9.3	19.7	7.7

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
76	8.8	5.8	6.6	11.3	5.4	8.4	9.4	19.7	7.8
77	8.8	5.8	6.6	11.4	5.3	8.5	9.4	19.8	7.8
78	8.8	5.8	6.6	11.4	5.4	8.5	9.4	19.7	7.8
79	8.8	5.8	6.6	11.5	5.4	8.5	9.4	19.8	7.8
80	8.8	5.8	6.6	11.6	5.4	8.6	9.3	19.8	7.9
81	8.8	5.8	6.7	11.6	5.3	8.6	9.1	19.9	8.2
82	8.8	5.7	6.8	11.9	5.0	9.0	8.4	19.9	8.7
83	8.8	5.7	6.8	11.9	5.0	9.0	8.3	20.0	8.7
84	8.8	5.7	6.8	11.9	5.0	9.0	8.3	20.0	8.8
85	8.8	5.8	6.8	12.0	5.0	9.0	8.4	20.2	9.0
86	8.8	5.8	6.8	12.1	5.0	9.0	8.3	20.2	9.2
87	8.8	5.8	6.8	12.1	5.05	9.0	8.3	20.2	9.3
88	8.7	5.9	6.8	12.0	5.0	9.0	8.5	20.3	9.3
89	8.7	5.9	6.8	12.0	5.0	9.0	8.5	20.3	9.5
90	8.7	5.9	6.8	12.0	5.1	9.0	8.5	20.3	9.6
91	8.7	5.9	6.8	12.0	5.1	9.0	8.5	20.3	9.8
92	8.7	6.0	6.8	12.0	5.2	9.0	8.5	20.1	10.2
93	8.7	6.0	6.8	12.1	5.2	9.0	8.5	20.1	10.3
94	8.7	6.0	6.8	12.1	5.2	9.0	8.6	20.2	10.3
95	8.7	6.1	6.7	12.1	5.2	8.9	8.7	20.2	10.4
96	8.7	6.1	6.7	12.1	5.2	8.9	8.7	20.3	10.5
97	8.7	6.1	6.7	12.1	5.2	8.9	8.7	20.2	10.4
98	8.7	6.2	6.8	12.1	5.3	9.0	8.8	20.3	10.8
99	8.7	6.2	6.8	12.1	5.3	9.0	8.9	20.3	10.8

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
100	8.7	6.2	6.8	12.3	5.3	9.0	9.0	20.3	11.0
101	8.7	6.2	6.8	12.3	5.3	9.0	9.0	20.3	11.1
102	8.7	6.2	6.8	12.4	5.3	9.0	9.0	20.2	11.0
103	8.7	6.2	6.8	12.4	5.3	9.0	9.0	20.2	11.1
104	8.7	6.2	6.8	12.5	5.4	9.0	8.9	20.3	11.1
105	8.7	6.3	6.8	12.5	5.4	9.0	8.8	20.1	11.3
106	8.7	6.3	6.8	12.5	5.4	9.0	8.8	20.1	11.5
107	8.7	6.3	6.8	12.5	5.4	9.1	8.8	20.1	11.5
108	8.7	6.3	6.8	12.5	5.4	9.0	8.8	20.2	11.6
109	8.7	6.3	6.8	12.6	5.4	9.0	8.8	20.3	11.7
110	8.7	6.3	6.8	12.7	5.4	9.0	8.7	20.3	11.6
111	8.7	6.3	6.8	12.8	5.3	8.9	8.7	20.3	11.9
112	8.7	6.3	6.8	12.8	5.2	8.8	8.6	20.3	11.9
113	8.7	6.4	6.8	12.8	5.2	8.8	8.6	20.3	12.2
114	8.7	6.4	6.8	12.8	5.3	8.8	8.6	20.6	12.3
115	8.7	6.4	6.8	12.7	5.3	8.8	8.5	20.6	12.4
116	8.7	6.4	6.8	12.8	5.4	8.8	8.4	20.6	12.6
117	8.7	6.4	6.8	12.8	5.4	8.7	8.4	20.6	13.0
118	8.7	6.4	6.8	12.8	5.4	8.7	8.4	20.6	13.0
119	8.7	6.4	6.8	12.8	5.4	8.7	8.4	20.7	13.1
120	8.7	6.4	6.7	12.8	5.4	8.6	8.4	20.6	13.1
121	8.7	6.4	6.7	12.8	5.4	8.7	8.4	20.6	13.1
122	8.7	6.4	6.7	12.8	5.4	8.8	8.3	20.5	13.3
123	8.6	6.4	6.7	12.8	5.4	8.8	8.3	20.6	13.5
124	8.6	6.4	6.7	12.8	5.4	8.8	8.3	20.6	13.4
125	8.6	6.4	6.7	12.9	5.4	8.8	8.4	20.7	13.4
126	8.6	6.4	6.7	12.9	5.3	8.8	8.5	20.6	13.4

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
1	12.9	18.1	9.8	3.3	12.4	112.9	42.9
2	12.9	17.9	9.6	3.3	12.2	112.4	42.9
3	12.9	17.9	9.6	3.3	12.0	112.2	42.99
4	13.0	17.9	9.5	3.3	12.0	111.0	42.9
5	13.0	18.0	9.5	3.3	11.1	110.0	42.9
6	12.7	17.9	9.5	3.3	10.7	108.0	42.25
7	12.8	17.8	9.5	3.3	10.4	106.8	42.25
8	12.8	17.6	9.6	3.3	10.7	106.55	42.25
9	12.7	17.6	9.6	3.3	9.8	105.6	42.25
10	12.7	17.7	9.5	3.3	9.6	104.3	42.3
11	12.7	17.6	9.3	3.3	9.1	103.8	41.7
12	12.7	17.7	9.3	3.1	8.9	103.6	41.4
13	11.8	18.0	9.4	3.1	8.1	104.1	40.7
14	11.9	18.0	9.4	3.1	7.4	103.9	40.7
15	11.9	18.0	9.4	3.1	7.2	103.4	41.0
16	11.8	17.9	9.4	3.1	7.2	103.3	41.0
17	11.9	18.0	9.4	3.1	6.9	102.3	40.7
18	11.7	18.0	9.4	3.1	6.3	101.0	40.4
19	11.7	18.0	9.2	3.1	6.3	99.7	40.3
20	11.7	17.9	9.2	3.1	6.3	99.5	40.0
21	11.3	18.7	9.2	2.9	6.8	98.2	40.0
22	11.2	18.6	9.2	2.9	6.6	98.0	39.3
23	11.2	18.6	9.2	2.8	6.6	96.5	39.0
24	11.2	18.5	9.4	2.6	6.6	96.0	39.0
25	11.2	18.5	9.4	2.6	6.6	95.3	39.0

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
26	11.2	18.5	9.4	2.6	6.6	94.5	39.0
27	11.2	18.5	9.4	2.6	5.9	93.4	38.9
28	11.2	18.4	9.4	2.6	5.7	91.7	38.9
29	11.3	18.3	9.7	2.6	5.2	90.2	38.3
30	11.2	18.3	9.5	2.6	5.2	88.6	37.6
31	11.2	18.3	9.2	2.6	5.5	87.3	37.6
32	11.2	18.3	9.2	2.6	5.2	86.7	36.9
33	10.8	18.3	9.2	2.6	5.0	85.7	36.9
34	10.7	18.3	9.2	2.6	4.8	84.9	36.9
35	10.6	18.3	9.2	2.6	4.8	83.3	36.5
36	10.6	18.3	9.2	2.6	4.8	82.3	36.0
37	11.1	18.1	9.2	2.5	4.6	81.4	35.1
38	11.0	17.9	9.2	2.5	4.6	80.4	34.5
39	11.0	17.8	9.2	2.5	4.6	79.6	34.2
40	11.0	17.8	9.1	2.5	4.6	78.5	33.8
42	11.0	17.8	8.9	2.5	3.9	77.8	32.2
43	11.1	17.8	8.9	2.5	3.9	77.5	31.7
44	11.0	17.7	8.9	2.5	3.9	77.0	31.7
45	10.9	17.6	9.2	2.2	3.5	77.7	31.9
46	11.1	17.6	9.2	2.2	3.5	78.0	31.9
47	11.1	17.6	9.2	2.2	3.5	78.2	31.9
48	11.1	17.5	9.2	2.2	3.5	79.5	31.6
49	11.2	17.5	9.2	2.2	3.7	79.5	31.6
50	11.2	17.4	9.2	2.2	3.7	78.7	31.2

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
51	11.3	17.4	9.2	2.2	3.7	78.5	30.9
52	11.5	17.4	9.2	2.2	3.9	78.0	30.9
53	11.5	17.4	9.2	2.2	3.9	77.5	30.9
54	11.4	17.2	9.2	2.2	3.9	77.2	30.6
55	11.2	16.5	8.8	2.5	3.9	76.0	30.6
56	11.2	16.6	9.0	2.5	3.9	75.7	30.6
57	11.2	16.6	8.8	2.6	3.9	75.2	30.5
58	11.2	16.6	8.8	2.6	3.9	75.5	30.5
59	11.1	16.7	8.8	2.6	3.9	75.7	30.5
60	11.1	16.7	8.8	2.6	3.9	75.7	30.5
61	11.4	16.6	8.8	2.6	3.9	76.0	30.5
62	11.4	16.7	8.8	2.6	3.9	76.0	30.5
63	11.5	16.7	8.8	2.6	3.9	75.5	30.5
64	11.6	16.7	8.8	2.6	3.9	75.5	30.5
65	11.6	16.8	8.6	2.4	3.9	76.0	30.5
66	11.6	16.8	8.6	2.4	3.9	76.0	30.5
67	11.4	17.1	8.3	2.4	3.9	75.8	30.1
68	11.4	17.5	8.2	2.4	3.9	75.8	30.1
69	11.4	17.5	8.2	2.4	3.7	75.8	30.1
70	11.4	17.6	8.3	2.4	3.7	75.8	30.1
71	11.5	17.7	8.3	2.4	3.5	76.5	30.1
72	11.5	17.7	8.3	2.4	3.5	77.0	30.1
73	11.5	18.0	8.1	2.4	3.5	77.2	30.1
74	11.8	18.0	8.1	2.4	3.5	77.7	30.1
75	11.9	18.1	8.3	2.4	3.3	77.7	30.1

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
76	12.0	18.3	8.3	2.4	3.3	78.0	30.1
77	12.0	18.3	8.3	2.4	3.3	78.0	30.1
78	12.0	18.3	8.3	2.4	3.3	78.2	30.5
79	12.0	18.4	8.3	2.4	3.3	78.2	30.5
80	12.0	18.4	8.3	2.4	3.3	78.7	30.5
81	12.2	18.2	8.0	2.9	3.3	78.5	30.5
82	11.7	18.6	8.3	3.1	3.3	78.9	30.5
83	11.7	18.6	8.3	3.1	3.3	78.6	31.2
84	11.7	18.7	8.1	3.1	3.5	79.1	31.2
85	11.6	18.7	8.2	3.1	3.5	79.1	31.2
86	11.8	18.7	8.2	3.1	3.5	79.4	31.2
87	11.8	19.2	8.2	3.1	3.5	80.2	31.2
88	11.7	19.3	8.2	3.1	3.3	81.2	31.2
89	11.6	19.4	8.2	3.1	3.3	81.2	31.2
90	11.8	19.5	8.5	3.1	3.3	81.7	31.2
91	11.8	19.6	8.5	3.1	3.3	82.2	31.2
92	12.0	19.7	8.5	3.1	3.3	83.0	31.2
93	12.1	19.8	8.3	3.1	3.3	83.3	31.2
94	12.1	19.8	8.3	3.1	3.3	83.6	31.2
95	12.2	19.8	8.3	3.1	3.3	83.6	31.2
96	12.2	19.8	8.3	3.1	3.3	83.6	31.2
97	12.2	19.8	8.3	3.1	3.3	83.6	31.2
98	12.3	19.7	8.2	3.1	3.3	84.1	31.2
99	12.1	19.7	8.2	3.1	3.3	84.4	31.2
100	12.1	20.0	8.3	3.1	3.3	85.0	31.2

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
101	12.1	20.0	8.3	3.1	3.3	85.0	31.2
102	12.1	20.0	8.5	3.1	3.3	85.0	31.2
103	12.1	20.2	8.5	3.1	3.3	85.2	31.2
104	12.1	20.4	8.6	3.1	3.3	85.8	31.2
105	12.2	20.6	8.5	3.1	3.3	86.3	31.2
106	12.2	21.4	8.9	3.1	3.3	86.8	31.2
107	12.2	21.5	8.9	3.1	3.3	87.0	31.2
108	12.4	21.6	8.6	3.1	3.3	87.3	31.2
109	12.4	21.7	8.9	3.1	3.3	87.6	31.2
110	12.4	21.9	8.9	3.1	3.3	88.7	31.2
111	12.3	21.9	9.2	3.1	3.3	89.0	31.2
112	12.3	22.3	9.2	2.9	3.1	89.5	31.2
113	12.3	22.5	9.2	2.9	3.1	89.7	31.2
114	12.4	23.5	9.2	2.9	3.1	90.2	31.2
115	12.5	23.6	9.4	2.9	2.9	89.9	31.5
116	12.5	23.6	9.4	2.9	2.9	90.5	31.5
117	12.5	23.6	9.4	2.9	2.9	90.0	31.5
118	12.1	23.5	9.4	2.9	2.9	89.7	31.8
119	12.2	23.5	9.4	2.9	2.9	89.4	31.8
120	12.3	23.5	9.4	2.9	2.9	89.9	31.8
121	12.2	23.7	9.4	2.9	2.7	89.7	31.8
122	12.2	23.7	9.5	2.9	2.7	90.4	32.1
123	12.2	23.4	9.5	2.9	2.5	90.4	32.4
124	12.2	23.4	9.2	2.9	2.5	90.7	32.7
125	12.3	23.4	9.2	2.9	2.3	91.5	32.7
126	12.3	23.4	9.2	2.9	2.3	92.4	32.7

Appendix F

Demanded Transportation Capacity.[10]

Month	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
1	5.1	9.8	13.9	3.9	8.2	7.1	7.7	15.8	7.9
2	5.1	10.0	14.2	3.9	8.1	7.2	7.7	15.9	7.7
3	5.2	9.9	14.15	4.0	8.15	7.1	7.6	16.0	7.5
4	5.2	9.8	14.2	3.9	8.0	7.3	7.4	15.8	7.2
5	5.2	9.7	14.2	4.0	7.8	7.1	7.1	15.6	7.1
6	5.2	9.9	14.1	3.95	7.9	7.3	7.1	15.5	7.4
7	5.2	9.8	14.25	4.0	7.9	7.05	7.1	15.75	7.5
8	5.1	9.8	14.2	3.9	8.0	7.3	7.0	16.0	7.6
9	5.2	9.5	14.0	3.85	7.8	7.4	6.85	16.1	7.7
10	5.2	9.6	14.2	4.0	7.9	7.4	6.8	16.2	7.9
11	5.1	9.6	14.2	3.8	7.7	7.2	6.7	16.0	8.1
12	5.0	9.5	14.1	3.7	7.7	7.0	6.8	16.1	7.9
13	4.9	9.3	14.0	3.3	7.3	8.3	5.3	16.8	7.7
14	4.9	9.4	14.2	3.5	7.5	8.2	5.3	16.7	8.0
15	4.9	9.4	14.2	3.5	7.4	8.2	5.3	16.7	7.8
16	4.8	9.3	14.1	3.6	7.5	8.4	5.3	16.8	7.9
17	5.0	9.8	14.5	3.5	7.4	8.5	5.3	16.6	8.1
18	4.9	9.6	14.4	3.6	7.4	8.4	5.2	16.7	8.2
19	4.8	9.3	14.2	3.5	7.3	8.5	5.1	16.6	8.1
20	4.7	9.2	14.0	3.5	7.3	8.4	5.0	16.5	7.9
21	4.6	8.9	14.2	3.7	7.2	8.7	4.9	16.5	8.0
22	4.8	9.0	14.0	3.6	7.3	8.7	4.9	16.3	7.9
23	4.8	9.0	14.0	3.6	7.1	8.9	4.9	16.1	7.6
24	4.8	8.9	14.2	3.5	7.2	9.2	4.9	16.1	8.1

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
25	9.0	4.6	6.8	9.5	5.5	9.1	8.2	15.9	8.0
26	8.9	4.7	6.8	9.6	5.5	8.7	8.3	16.0	8.1
27	8.9	4.8	6.9	10.0	5.5	8.8	8.4	16.0	8.2
28	8.9	4.8	6.8	9.7	5.5	8.9	8.4	15.9	7.8
29	8.9	5.0	6.5	9.4	5.6	8.5	8.6	16.0	7.9
30	8.8	5.0	6.5	9.4	5.1	8.3	8.7	16.2	7.9
31	8.8	4.9	6.5	9.5	5.7	8.2	8.9	16.1	7.7
32	8.7	5.1	6.6	9.6	5.7	8.2	9.0	16.1	7.9
33	8.6	5.0	6.7	9.5	5.8	8.3	8.9	16.2	7.8
34	8.6	5.0	6.6	9.6	5.7	8.3	8.9	16.0	7.7
35	8.6	5.0	6.6	9.6	5.7	8.3	8.9	16.3	7.7
36	8.6	5.0	6.5	9.6	5.8	8.2	8.6	16.3	7.8
37	8.5	5.1	6.3	9.5	5.9	8.1	8.7	16.6	7.5
38	8.4	5.2	6.2	9.7	5.9	8.1	8.6	16.5	7.4
39	8.5	5.3	6.2	9.6	6.0	8.0	8.7	16.5	7.5
40	8.5	5.2	6.2	9.4	5.9	8.2	8.8	16.6	7.2
41	8.7	5.3	6.3	10.0	5.9	8.2	8.7	16.7	7.2
42	8.7	5.3	6.3	9.9	5.8	8.3	8.7	16.8	7.1
43	8.8	5.3	6.5	9.6	5.6	8.2	8.9	16.7	7.0
44	8.8	5.3	6.5	9.7	5.5	8.2	9.0	16.8	7.0
45	8.7	5.5	6.5	9.7	5.6	8.1	8.7	16.9	7.3
46	8.7	5.5	6.4	9.8	5.6	8.1	8.7	16.8	7.5
47	8.8	5.5	6.5	9.8	5.5	8.0	8.8	17.0	7.4
48	8.8	5.4	6.3	9.8	5.5	8.0	8.9	16.8	7.6
49	8.8	5.6	6.4	9.9	5.5	8.0	8.7	17.1	7.6
50	8.7	5.6	6.5	9.9	5.3	8.0	8.9	17.2	7.6
51	8.7	5.6	6.5	9.9	5.2	8.1	8.8	17.1	7.6

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
52	8.8	5.6	6.5	10.1	5.2	8.1	8.9	17.1	7.5
53	8.8	5.7	6.6	10.0	5.1	8.2	9.1	17.5	7.6
54	8.8	5.7	6.6	10.1	5.1	8.1	9.1	17.4	7.6
55	8.7	5.5	6.5	9.7	5.2	7.8	9.3	17.5	7.9
56	8.7	5.5	6.4	9.7	5.2	8.0	9.4	17.6	7.8
57	8.7	5.4	6.5	9.8	5.4	8.0	8.9	18.4	7.8
58	8.7	5.4	6.5	9.8	5.5	8.0	8.9	18.3	8.0
59	8.7	5.6	6.5	9.7	5.6	8.0	8.9	18.1	7.6
60	8.7	5.5	6.5	9.9	5.6	7.9	8.8	18.0	8.1
61	8.8	5.5	6.5	10.1	5.5	8.0	8.7	18.3	8.1
62	8.8	5.5	6.5	10.1	5.5	8.0	8.7	18.3	8.1
63	8.7	5.6	6.5	10.1	5.6	8.0	8.8	18.5	7.8
64	8.7	5.6	6.5	10.4	5.6	8.0	9.0	18.5	7.9
65	8.6	5.5	6.5	10.3	5.5	8.0	9.0	18.6	7.8
66	8.6	5.6	6.5	10.3	5.5	8.1	9.0	18.5	7.8
67	8.5	5.6	6.5	10.4	5.3	8.2	8.8	19.0	7.4
68	8.5	5.6	6.5	10.5	5.2	8.1	8.9	19.1	7.5
69	8.5	5.6	6.5	10.5	5.2	8.1	8.9	19.0	7.4
70	8.6	5.6	6.5	10.6	5.0	8.1	8.9	18.9	7.3
71	8.5	5.6	6.5	10.9	5.2	8.1	8.9	18.9	7.3
72	8.5	5.7	6.5	10.9	5.3	8.1	8.9	19.2	7.3
73	8.5	5.8	6.5	10.9	5.2	8.1	9.0	19.1	7.3
74	8.5	5.7	6.4	11.1	5.3	8.3	9.1	19.2	7.2
75	8.5	5.7	6.5	11.1	5.3	8.3	8.9	19.2	7.3

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
76	8.5	5.6	6.5	10.8	5.3	8.3	8.9	19.1	7.4
77	8.5	5.7	6.5	11.0	5.2	8.4	9.1	19.4	7.3
78	8.5	5.8	6.5	11.0	5.3	8.4	9.1	19.2	7.4
79	8.5	5.8	6.5	11.0	5.3	8.4	9.0	19.3	7.4
80	8.4	5.8	6.4	11.1	5.3	8.5	8.9	19.3	7.5
81	8.5	5.7	6.6	11.2	5.2	8.4	8.7	19.3	7.9
82	8.5	5.6	6.7	11.5	4.9	8.9	8.1	19.5	8.2
83	8.5	5.6	6.7	11.6	4.9	8.9	7.9	19.7	8.3
84	8.6	5.6	6.7	11.5	4.9	8.9	7.9	19.7	8.4
85	8.6	5.7	6.7	11.6	4.9	8.8	7.9	19.8	8.6
86	8.6	5.7	6.6	11.3	4.9	8.8	8.0	19.8	8.7
87	8.6	5.7	6.6	11.7	5.0	8.8	8.1	19.8	8.9
88	8.5	5.8	6.7	11.5	4.9	8.8	8.1	19.8	8.9
89	8.5	5.7	6.7	11.7	4.9	8.8	8.2	19.9	9.1
90	8.5	5.7	6.7	11.7	5.0	8.9	8.2	19.7	9.4
91	8.5	5.7	6.6	11.8	5.0	8.9	8.4	19.8	9.4
92	8.5	5.8	6.6	11.8	5.1	8.8	8.3	19.6	9.8
93	8.5	5.8	6.6	11.8	5.1	8.8	8.4	19.6	9.9
94	8.5	5.8	6.7	11.8	5.1	8.9	8.4	19.6	9.8
95	8.4	5.9	6.6	11.8	5.1	8.8	8.5	19.5	10.0
96	8.4	6.0	6.5	11.8	5.1	8.8	8.2	19.7	10.1
97	8.4	6.0	6.5	11.8	5.1	8.8	8.2	19.7	10.1
98	8.5	6.0	6.7	11.6	5.2	8.9	8.4	19.6	10.4
99	8.5	6.1	6.6	11.7	5.2	8.9	8.5	19.6	10.5
100	8.5	6.0	6.6	12.0	5.2	8.8	8.5	19.6	10.7

Month	10-25	25-30	30-35	35-45	45-55	55-65	65-80	80-90	90-100
101	8.5	6.1	6.6	11.9	5.2	8.8	8.6	19.6	10.8
102	8.4	6.1	6.7	11.9	5.2	8.8	8.5	19.5	10.5
103	8.5	6.1	6.6	12.1	5.2	8.8	8.5	19.6	10.5
104	8.4	6.1	6.6	12.1	5.2	8.8	8.2	19.6	10.5
105	8.4	6.1	6.5	12.1	5.1	8.8	8.2	19.2	10.7
106	8.4	6.1	6.6	12.1	5.2	8.8	8.4	19.1	11.0
107	8.4	6.1	6.6	12.0	5.2	8.9	8.4	19.5	10.6
108	8.4	6.1	6.6	11.9	5.1	8.8	8.2	19.4	11.1
109	8.4	6.1	6.6	12.2	5.1	8.8	8.3	19.4	11.1
110	8.3	6.1	6.6	12.2	5.1	8.8	8.1	19.5	11.1
111	8.3	6.1	6.6	12.3	5.0	8.7	8.1	19.4	11.3
112	8.3	6.0	6.5	12.2	5.0	8.7	7.9	19.5	11.3
113	8.3	6.2	6.3	12.3	5.0	8.6	7.9	19.4	11.7
114	8.2	6.2	6.4	12.3	5.1	8.6	7.9	19.8	11.8
115	8.3	6.2	6.5	12.3	5.1	8.7	7.8	19.9	11.8
116	8.3	6.2	6.6	12.2	5.2	8.7	7.8	19.9	11.9
117	8.2	6.2	6.6	12.2	5.2	8.5	7.8	19.8	12.3
118	8.2	6.2	6.6	12.1	5.2	8.5	7.8	19.8	12.2
119	8.1	6.2	6.6	12.2	5.2	8.5	7.7	19.9	12.4
120	8.1	6.2	6.5	12.2	5.2	8.4	7.7	19.8	12.4
121	8.2	6.3	6.5	12.3	5.2	8.5	8.0	19.5	12.3
122	8.2	6.3	6.6	12.3	5.3	8.6	7.7	19.4	12.2
123	8.1	6.3	6.6	12.3	5.3	8.7	7.7	19.5	12.4
124	7.9	6.3	6.6	12.3	5.3	8.6	7.8	19.6	12.2
125	8.0	6.2	6.4	12.6	5.2	8.7	7.8	19.7	12.3
126	8.1	6.	3 6.4	12.6	5.1	8.6	8.0	19.8	12.7

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
1	11.5	14.8	8.4	3.1	7.4	76.8	25.3
2	11.4	14.5	8.2	3.1	6.7	75.9	21.8
3	11.3	14.7	8.0	3.1	6.5	72.7	20.6
4	11.4	14.8	7.9	2.9	6.5	71.8	19.3
5	11.5	13.9	7.4	3.1	6.1	67.8	18.4
6	11.3	14.3	7.3	3.1	6.1	67.9	18.9
7	11.4	14.15	7.6	3.1	5.85	68.1	18.2
8	11.3	14.4	7.4	3.1	6.5	69.35	20.6
9	11.3	14.95	7.4	3.3	5.6	68.65	21.0
10	11.6	15.2	7.6	3.3	5.9	70.1	21.2
11	11.4	15.4	6.8	3.3	5.9	70.6	22.4
12	11.65	15.6	7.0	3.1	6.1	69.3	22.3
13	11.0	15.8	7.5	3.1	5.9	68.7	22.0
14	11.0	16.4	7.5	3.1	5.2	65.8	20.7
15	11.2	16.2	7.3	3.1	4.8	65.6	19.8
16	11.3	16.4	7.0	3.1	4.6	63.9	19.7
17	11.3	16.5	7.7	3.1	4.3	62.8	20.4
18	10.9	16.6	8.1	3.1	4.3	62.0	20.1
19	11.0	16.8	7.8	3.1	4.1	62.9	20.8
20	10.9	16.9	7.8	3.1	4.5	65.0	21.8
21	10.5	17.7	8.1	2.9	5.0	61.6	19.4
22	10.9	17.5	7.6	2.9	4.4	61.9	19.0
23	10.8	17.5	8.5	2.8	4.4	59.3	17.3
24	10.6	17.2	7.6	2.6	4.1	60.3	18.9
25	10.4	17.2	7.5	2.6	4.1	60.5	18.4

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
26	10.5	15.4	7.5	2.6	5.0	58.8	17.6
27	10.5	17.4	7.3	2.6	4.6	59.8	18.5
28	10.4	17.2	7.5	2.6	4.4	57.0	16.2
29	10.3	17.1	7.6	2.6	4.1	55.2	15.9
30	10.1	17.1	7.7	2.6	3.9	53.0	14.5
31	10.1	16.9	7.8	2.6	4.6	51.7	14.5
32	9.6	16.5	7.8	2.6	4.1	49.4	15.5
33	9.4	17.2	8.1	2.6	4.1	48.3	13.9
34	9.7	17.2	8.1	2.6	3.5	48.7	15.7
35	9.7	17.3	8.1	2.6	3.5	49.6	15.0
36	9.7	17.5	8.1	2.6	3.5	54.1	18.6
37	10.4	17.4	8.4	2.5	3.7	55.9	18.6
38	10.4	17.1	8.3	2.5	3.5	55.6	17.6
39	10.4	16.5	8.3	2.5	3.3	55.6	18.1
40	10.4	16.5	8.0	2.5	3.3	56.4	18.4
41	10.3	16.1	7.8	2.5	2.8	55.6	17.6
42	10.3	16.1	7.5	2.5	2.8	55.5	18.4
43	10.5	16.4	7.9	2.5	2.8	57.2	18.9
44	10.4	16.4	8.1	2.5	2.8	59.4	21.7
45	10.3	16.6	8.5	2.2	2.6	62.1	23.9
46	10.4	16.7	8.5	2.2	2.6	62.0	23.2
47	10.5	16.5	8.5	2.2	2.2	60.6	22.2
48	10.5	16.5	8.5	2.2	2.2	60.8	20.0
49	10.6	16.4	8.5	2.2	2.6	61.9	20.2
50	10.8	16.5	8.5	2.2	3.0	61.6	19.6

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
51	10.8	16.7	8.3	2.2	3.0	61.6	19.3
52	10.8	16.5	8.1	2.2	3.2	61.3	18.5
53	10.6	16.5	8.3	2.2	3.2	60.3	18.3
54	10.5	16.7	8.3	2.2	3.0	60.1	18.1
55	10.4	16.2	8.3	2.5	3.0	60.1	17.0
56	10.5	16.2	8.2	2.5	3.0	61.7	18.1
57	10.6	16.2	8.2	2.6	3.0	63.1	18.4
58	11.0	16.1	8.5	2.4	2.8	63.9	17.6
59	10.8	16.1	8.3	2.4	2.6	62.6	18.0
60	10.8	16.0	8.3	2.4	2.2	64.7	18.4
61	10.8	16.1	8.2	2.3	2.8	63.7	18.8
62	10.8	16.1	8.2	2.3	2.8	63.7	18.8
63	11.2	16.2	8.0	2.6	3.1	66.6	18.0
64	11.4	16.4	8.2	2.6	3.1	65.5	17.1
65	11.4	16.5	8.2	2.4	3.1	65.6	17.8
66	11.1	16.2	8.3	2.4	2.6	65.9	18.7
67	10.7	16.4	7.7	2.4	2.4	65.4	18.7
68	11.1	16.9	7.4	2.4	2.8	66.2	20.9
69	11.1	16.9	7.4	2.4	2.6	66.2	20.9
70	11.0	17.2	8.0	2.4	2.6	66.0	20.7
71	11.2	17.4	8.0	2.4	3.0	67.5	23.4
72	11.3	17.3	8.2	2.4	3.3	67.9	23.8
73	11.2	17.7	7.8	2.4	3.3	68.6	22.7
74	11.4	17.7	7.9	2.4	3.1	71.5	23.7
75	11.2	17.7	8.2	2.2	2.4	71.2	22.6

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
76	11.6	18.0	8.2	2.2	2.8	70.7	23.6
77	11.7	17.7	8.0	2.2	2.8	70.6	24.1
78	11.8	17.9	8.2	2.2	3.3	71.7	25.1
79	11.6	18.0	7.8	2.2	3.1	71.2	24.2
80	11.6	18.0	7.8	2.2	3.1	71.0	23.6
81	11.8	17.7	7.5	2.7	2.4	71.5	21.1
82	11.4	18.1	7.8	2.9	2.7	72.2	21.9
83	11.4	18.2	7.8	2.9	2.7	72.2	23.8
84	11.4	18.3	7.8	2.9	2.6	71.6	24.9
85	11.2	18.3	7.7	2.9	2.6	71.3	25.8
86	11.5	18.1	7.7	2.9	2.6	71.8	25.8
87	11.1	18.4	7.9	2.9	2.9	73.2	25.6
88	11.2	18.7	7.9	2.9	2.7	73.1	26.0
89	11.1	18.7	7.6	2.9	2.7	73.9	26.0
90	11.4	18.6	8.0	2.9	2.8	73.9	26.3
91	11.1	18.6	7.9	2.9	2.6	74.4	26.0
92	11.4	18.9	7.9	2.9	2.9	74.4	24.7
93	11.7	19.0	7.7	2.9	3.1	75.8	26.2
94	11.7	18.8	7.5	2.9	2.6	77.3	25.9
95	11.8	18.7	7.4	2.9	2.6	77.3	26.2
96	12.0	18.6	7.7	2.7	2.9	76.5	25.5
97	12.0	18.6	7.7	2.7	2.9	76.5	25.5
98	11.8	18.3	7.1	2.9	2.9	75.9	27.3
99	11.8	18.3	7.1	2.9	2.9	76.4	27.3
100	11.6	19.5	6.9	2.9	2.6	77.5	26.6

Month	100-125	125-150	150-175	175-200	200-225	225-300	300+
101	11.6	18.8	7.1	2.9	2.6	78.1	26.6
102	11.7	18.9	7.4	2.7	2.9	76.8	25.6
103	11.5	19.1	7.4	2.7	2.9	77.3	26.3
104	11.5	18.9	7.4	2.7	2.8	75.9	26.7
105	11.8	19.1	7.3	2.4	3.1	76.7	27.3
106	11.6	20.0	7.4	2.7	2.9	76.7	27.0
107	11.6	20.1	7.7	2.7	2.4	77.3	27.2
108	11.9	20.8	7.5	2.7	2.4	79.2	26.6
109	11.7	20.6	7.7	2.7	2.4	78.7	26.8
110	11.7	20.5	7.5	2.7	2.6	80.3	26.9
111	11.7	20.9	8.0	2.7	2.6	80.9	26.6
112	11.9	21.2	8.1	2.5	2.2	81.5	27.3
113	11.7	21.3	7.8	2.5	2.2	82.8	26.4
114	11.8	22.1	7.8	2.7	2.2	80.4	26.7
115	11.7	22.5	8.0	2.7	2.0	80.6	26.6
116	11.8	22.2	7.5	2.5	2.2	81.2	26.0
117	11.9	22.1	7.4	2.5	2.2	80.9	25.6
118	11.8	21.8	7.7	2.5	2.0	80.4	27.3
119	11.8	21.4	7.5	2.5	2.0	80.0	27.2
120	11.9	21.4	7.5	2.5	2.0	80.5	27.2
121	11.4	21.7	6.7	2.4	1.8	82.1	27.4
122	11.4	21.9	7.1	2.5	1.6	84.6	28.7
123	11.6	21.6	7.3	2.5	1.4	84.9	27.9
124	11.3	21.0	6.8	2.5	1.6	85.2	27.9
125	11.4	21.3	6.8	2.5	1.9	84.4	27.3
126	11.0	21.5	7.3	2.7	1.9	84.5	26.9