WAVES AND OIL TANKERS - DYNAMICS OF THE MARKET FOR OIL TANKERS TO THE YEAR 2000

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Introduction

The oil tanker market is interesting from a system dynamics point of view. The market exhibits regularities which appear to be caused by an underlying structure which has been stable for at least 30 years, and probably longer. This seemingly stable structure is primarily the result of the systematic, but not particularly rational, behaviour of the main actor in the oil tanker market: the community of shipowners. The collective effect of their individualistic actions, I believe, is a rather violent and rhythmic development in the market - on a timescale of years to decades. The regularity is, of course, superimposed on a non-recurring pattern of developments caused by events entirely outside the control of the oil tanker community. In this paper I describe the stable structure and discuss what it means for the likely development of the oil tanker market over the next decade.

This paper is based on work done in the Resource Policy Group over the last 6 years. I owe great thanks to Mess. Ulrich Golüke, Christoph Endress, Per Axel Prydz and Lasse Franck who have all toiled at various times, to concretize what was initially a hunch to what is now a well documented model of one possible explanation of the development of the market for oil tankers.[1]

The market for oil tankers

As is well known, much of the world's crude oil is produced far away (in the Arabian Gulf and Venezuela) from where the oil is used (in Europe, Japan and in the US). To get the oil to its destination, the oil is pumped aboard oil tankers. These are large ships of ever increasing size, currently capable of carrying up to 500 000 tons of oil in a single load. Today there are around 1000 oil tankers in the world, varying between approximately 20 000 and 500 000 tdw (tons dead weight)[2]. Together they transport around 2000 million tons of oil every year over an average distance of 6000 miles. This means that roughly one half of all the oil used in the world has once spent up to a month on board a vessel travelling across the high seas. Figure 1 illustrates the pattern of oceanborne oil transport in 1978.

The oil companies own 40% of the world's oil tankers. The rest are held by independent shipowners - in Greece, Hong Kong, Norway, Liberia and elsewhere. The independents let their ships to the oil companies, either on a period basis ("time charter") or for a single trip ("spot"). Typically, 40% of the tanker fleet is engaged in time charters of varying duration. Only the remaining 20% (varying between 10 and 30% over the last 30 years) of the total fleet operates in the spot market, being available for single trips. But in this small part of the market ordinary variations in the total supply and demand for oil tankers are amplified into violent booms and busts. And here fortunes are quickly made and lost. In the spot market one can feel the pulse of the market, not only from hour to hour, but from minute to minute. The spot market for oil tanker transport is probably one of the best existing approximations to the "perfect" market, with hundreds of brokers and thousands of telex lines continuously transmitting information about available ships and cargoes.

The shipping crisis of the 1970's

The extent of oceanborne oil transport grew spectacularly before 1973. First because the industrialized countries consumed growing quantities of oil in their cars, houses and factories, but also because they exhausted traditional oil reservoirs near home and were forced to go farther and farther away for new supplies. At the time of the OPEC quadrupling of oil prices in 1973, the US shipped in 1/3 of its oil consumption and Europe most of hers. Much of the oil comes from the Arabian Gulf, 12 000 and 10 000 miles away, respectively. After 1973 the tanker market has been less expansive. Both because growth in oil consumption has been lower and because new oil fields have started producing nearer home (Alaska, Mexico, The North Sea). The demand for oil transport over the last 30 years is illustrated to the left in figure 2.

The period of stagnation throughout the 1970's did create problems of overcapacity in the oil tanker market. There were too many ships available competing for a limited number of cargoes. The immediate reason is obvious: Tankers must be ordered between 1 and 3 years before they are delivered from the shipyard. And the boom years just prior to the OPEC embargo gave the shipowners all the cash and all the incentive necessary to place orders for new, and larger, ships. At the peak, in late 1973, there was nearly as much tonnage on order as there was tonnage afloat. And once an order has been placed, it is expensive to cancel. Rather than accepting "unnecessary" cancellation charges, the shipowners chose to hope for a brighter future and took delivery on a lasting stream of new ships, even though many went directly to year-long stays anchored in some remote Norwegian fjord or elsewhere.

The ships that still did transport oil received very low rates. As a consequence they often moved at reduced speed ("slow-steaming") to minimize fuel costs. At the bottom of the shipping crisis the actual transport work performed was only one half of the capacity of the existing fleet. The other half of the tonnage was either laid up or absorbed in slow-steaming. In short, capacity utilization of the world's oil tankers was down to 50%.

The development is visualized in the top part of figure 3. Today's (1981) situation is a continuation of the gloomy 1970's, although the order backlog for new tonnage now is minimal.

Recurring crises

The conventional wisdom of the shipping community is that the crisis of the 1970's was a one-time affair caused by unpredictable development outside the control of the community, namely the "oil crisis" created by OPEC.

I do not think that conclusion holds. If one looks further back in time, the developments following 1973 seem to be mirrored by the events between 1956 and the middle 1960's. Both periods display the same pattern: An initial couple of years of exceedingly high profits, followed by phenomenal growth in the order backlog for oil tankers, followed by a lasting period of low rates, significant lay-ups, and low capacity utilization. The depression lasts for as long as the steady flow of new ships create and maintain overcapacity. It only ends when growth in the demand for oil transport and scrapping of old ships finally restore balance in the market. The development from 1956 onward is also visualized in figure 3. The similarity to the 1970's is obvious.

If we go even further back, verbal description tell of a similar sequence of events in the 1930's, which gave Tjalling Koopmans an incentive to write his classic Tanker Freight Rates and Tankship Building in 1939.

In summary, a decade long period of overcapacity seems to be a recurring phenomenon in the market for oil tankers.

More waves in the tanker market

The recurring periods of overcapacity show up, of course, in the time development of the freight rate (that is, in the price paid for transport of oil, measured in $/ton-mile). Figure 4 portrays the actual development of the freight rate over the last 30 years[3].

During the two periods of overcapacity, lay-ups and slow-steaming, (1958-1967 and 1974 till today), the freight rate remained consistently low - as one would expect. The Worldscale index fluctuated around 40. Whenever the index increased some, new ships were lured out of lay-up while others increased their speed. And predictably, the Worldscale numbers once more were pushed back to the minimum level that could keep sufficient tonnage operating.

To the system dynamicist, however, figure 4 is more interesting for what it says about the intervals between the periods of overcapacity. It would be reasonable to expect intervals of undercapacity - intervals with a lack of tonnage as a result of insufficient investment in new ships during the preceeding period of overcapacity and low profits. But figure 4 does not show a high and stable rate during these intervals (1950-1957, 1967-1973). Rather we see violent fluctuations between peaks near Worldscale 400 (where a few month-long trips yield sufficient profit to pay down an entire tanker) and troughs below Worldscale 100. So although the average rate during these intervals is higher, it is very unstable.

Our central hypothesis

The instability is not random, however, at least for one who wants to see regularity. The rate appears to fluctuate with a four-year period which immediately brings to mind inventory oscillations and the 3-6 year business cycle. And this was the initial hunch behind our study of the dynamics of the oil tanker market. We interpreted the freight rate development as a sum of one 20 (actually 15-20) year wave and one 4 (actually 3-6) year wave, as sketched in figure 5. The top curve is ment to represent the 4 year business cycle which we assumed is felt in the tanker market as a 4-year oscillation in the demand for oil. The middle curve shows a 20-year investment cycle, where we assumed that the observed 10-year periods of overcapacity are succeeded by intervals of undercapacity in the supply of ships. The lower curve in figure 5 shows the interaction of the two waves.

Notice that we assumed that the business cycle does not show up in the freight rate during periods of overcapacity. When there is still free capacity, - ships laid-up or going at less than full steam - increased demand simply leads to increased supply, possibly after a brief period of higher rates. But in the intervals of scarce capacity, when there are no lay-ups or slow-steaming, even small demand increases will push rates sky-high. This was our hypothesis for the asymmetric rate development seen in figure 4 - our reference mode.

We did know, however, that the amplitude in the fluctuations in GNP and hence in the demand for oil is at most $\pm$ 5% over the 4-year cycle. The freight rate, on the other hand, varies with several hundred per cent. One possible explanation could be the existence of a 4-year oscillatory tendency in the tanker market itself, tending to amplify the swings in the demand.

Further, an investment wave period of 20 years seemed long given that the order delay for new ships rarely exceeds 3 years, and is around 1 in the normal situation with ample shipyard capacity. One possible explanation could be that perception and decision delays become especially long because the market development appears random, violent and confusing to the community of shipowners.

The basic structure

Much work, discussion with industry people, review of existing literature, and numerous tests and revisions of our model, have led us to believe in the basic structure below. In short, this is a structure dominated by a 20-year investment loop with very significant decision delays. There is, however, no single strong 4-year loop (although a number of weak ones) and we have concluded that the violent fluctuations in the freight rate in response to soft fluctuations in the demand for oil is largely a consequence of very inelastic supply once the oil tanker market is near or above full capacity utilization.

The basic structure of our model is shown in figure 6. This apparently trivial diagram warrants a number of comments.

First, the freight rate is assumed to depend on the demand for oil transport compared to the capacity of the existing fleet of tankers. The higher the demand, the higher the rate. The important point here is our belief that the freight rate depends on demand relative to the capacity of the whole existing fleet, and not relative to the capacity of the tonnage that is currently sailing. In other words: we assume that freight rates will not soar as long as there is capacity available in lay-ups or slow-steaming, even if the ships that do sail are working at full capacity. The experience of the 1970's establishes this view beyond dispute.

Still, a short term dynamic exists, whereby the freight rate goes up temporarily when the sailing fleet is pressed beyond reasonable utilization. But the higher rate will immediately draw additional ships out of lay-up. Soon there will be enough tonnage sailing to perform the current oil transports with reasonable vessel utilization and - hence - for a reasonable rate. This short term dynamic can be seen as a tendency for a 1-year oscillation in figure 4. It is included in the model.

Second, returning to figure 6, the demand for oil transport obviously depends on the consumption of oil, which in turn depends on the level of economic activity. An important structural element, however, is the fact that there is no (or at most, a very weak) link between the freight rate and the demand for oil transport (dotted in figure 6). The cost of transporting oil (usually below 1 $/barrel) is so much lower than the value of oil (around 35$/barrel), that even record high rates have little effect on the market price, and hence consumption, of oil.

Third, we believe there is some effect from the inventory of oil, decoupling the consumption of oil from the oil transports performed. We see all oil in transit between oil field and end consumer as the relevant inventory. The size of this inventory appears to be between 3 and 6 months - 1 month's supply are on board the oil tankers; refineries and retailers store another 1-2 month's sales, while the consumer stores the same in his house or factory. When there is much oil in transit, we would expect this to reduce the orders for new cargoes of oil. The delay around the loop is roughly one year. The loop therefore is interesting because it might amplify an exogenous 4-year oscillation in the oil consumption. We have, however, not yet been able to gather the necessary statistics to investigate this possibility. Oil transport statistics do not exist in an aggregated form on a quarterly (or monthly) basis, and the industrialized countries did not start to gather aggregated inventory statistics until very recently. So although included in the model, the relation between inventory and the demand for oil transports has been tuned so as not to generate a dominant 4-year oscillatory tendency.

Fourth, we believe that the impact of the freight rate on the market for oil tankers is primarily on the supply side. Given the cost structure of the ships, the freight rate determines what is optimal behaviour for the shipowners concerning whether to lay up, to slow steam, to perform extended maintenance and repairs, etc. The aggregated result of the individual decisions of hundreds of shipowners is a certain program of utilization for the existing fleet. In short: the freight rate determines the capacity utilization of the fleet. The effect is quick: the decision to slow-steam can be made within hours (if the contract allows), and all decisions on vessel utilization can be redone when the current contract expires[4].

Fifth, as long as the fleet is operating below capacity, the amount of oil transported will be equal to the demand for oil transports. Over the last 20 years, there has only been a very few months where the existing fleet operated above 80% of capacity. In other words, there has consistently been ample spare capacity, and shipments have equalled orders. One likely effect of this is that fluctuations in the oil consumption do not result so much in varying oil inventories as in varying capacity utilization in the tanker market. The market may, so to speak, be the buffer. And not only absorbing the inventory oscillations, but also the 4-year business cycle. We have done much work to try and illustrate this effect statistically, but even our best results remain unimpressive due to lack of data and the shrouding effect of technical developments[5].

Sixth, we assume that the total transport capacity, i.e. the total number of ships, develops primarily in response to the shipowners' perception of the capacity utilization. High freight rates may tempt owners to order new ships, but high rates is not enough, we believe, to make him commit tens of millions of dollars. First he will make sure that all existing ships have (or will have) employment, i.e. that capacity utilization is (or will be) at acceptable levels. Only then will he go ahead and place his order.

Still, we do not imply that the ordering is a cool and rational process. There are large uncertainties associated with demand development, future technology, scrapping of old ships, and potential cancellation of orders. And there are psychological effects which make it difficult to remain unperturbed by the current mood of the trade. All these factors may add up to large scale ordering even when cool analysis reveals overcapacity in the near future. But basically we believe that new ships are ordered when continuation of current trends indicates excessive levels of capacity utilization within a couple of years.

Finally, we stress the dominant role of the investment loop (freight rate → capacity utilization → total transport capacity → freight rate) in figure 6. The total number of ships can only be changed through orders for new ships or scrapping of old ships. These are slow processes. Still, I believe, they dominate developments - even if low freight rates may result in quick cancellations of new orders, and high rates may lead to immediate postponement of scrapping plans. Thus, in very rough terms, I see the oil tanker market as a 20-year investment loop, driven by an exogenous demand for oil which includes a 4-year business cycle component. Short term variations in the demand for oil transport are reflected in the capacity utilization of the fleet, and may be amplified some by endogenous inventory dynamics. During periods of scarce transport capacity, the variations also show up in the freight rate.

Our model reflects these views.

The model

The current version of our DYNAMO model (documented in GRS-315, see note 1) of the market for oil tankers comprises 300 equations. Different parts of the model describe the demand for oil transport; the capacity, age structure and cost structure of the existing fleet; the shipowners' decisions on how to utilize the fleet; the formation of expectations and the decisions on investment in new ships/scrapping of old ships; and, finally, the ability of the shipyards to handle new orders for ships.

Most of the formulations have been discussed extensively with practitioners in the shipping industry. Consequently, the equations are more directly descriptive of real world procedures and less "streamlined system dynamics formulations". Industry wording have been used throughout, and there is little disagreement about the centrality of the relations that are included in the model. Practitioner criticism typically focuses on a number of mechanisms that have not been included. These mechanisms were excluded because we do not believe they are sufficiently stable over time to be part of a fundamental explanation of the causes behind our 30-year long reference mode. In short, the detailed model formulations and the main parameter values have passed the test of being plausible to practitioners. One evidence is the fact that the Norwegian Ministry of Trade and Shipping does make model runs as an input to decisions which require an opinion on the long term development (say, to 1990) of the market for oil tankers.

The model was tested by trying to reproduce historical tanker market behaviour from 1953-1980. The model was initiated with the values for 1953 and only subjected to the actual rates of growth of the exogenous variables (oil consumption and average transport distance) and random disturbances in oil consumption. The result is summarized in figure 3.

As can be seen from the figure the model is able to recreate the observed pattern of 10 years of overcapacity succeeded by intervals of undercapacity. Furthermore, lay-ups, tonnage on order, and the growth of the tanker fleet are also reproduced. The phase relationships observed in reality, high lay-ups at the beginning of the extended depression and increasing orders during successive booms are also reflected in the model simulation. The model also does recreate the wild swings in the freight rate, although only driven by a very soft tendency to a 4-year cycle in the historical figures for global oil consumption. In short, our relatively simple hypotheses are capable of recreating the rather complex historical developments over the last 30 years.

Finally, the model system is robust against reasonable changes, both in parameters and exogenous functions. This will be seen from the model experiments discussed below.

<u>A system's view</u>

But even without model experiments, we can draw some "system's" conclusions about the market for oil tankers. These are conclusions that rely on the basic system structure and therefore, I believe, will remain valid for a long time. In a way these conclusions are the main practical results of our study, because they can be transmitted and defended in words.

1. The <u>level of activity</u> in the tanker market is primarily determined by the demand for seaborne transport of oil - which, of course, is determined <u>outside</u> the shipping sector. In short, the volume of the tanker market is determined by the rest of the world.

2. The <u>profitability</u> of the sector, on the other hand, is determined by the degree of match between supply of and demand for oil transport. And the supply (the number of ships and the way they are used) is, of course, fully determined by the <u>shipowners themselves</u>. In short, the sector determines its own profitability.

3. Flippantly, but with a large element of truth: in the future the level of activity in the tanker market will be determined by the world's demand for oil transport, while the profitability will be determined by the shipowners' supply of oil tankers. When freight rates are low, it signals less than perfect co-operation among shipowners. This is particularly true when considering that transport costs represent a minute fraction of the cost of oil.

4. Major freight rate increases will only occur during intervals of undercapacity (i.e. when most vessels are fully employed). This is true regardless of whether the boom is caused by a business cycle upturn or by random events like the closing of the Suez Canal in 1967. If such boom impulses occur during a period of significant lay-ups and slow-steaming, they will hardly result in anything but fewer lay-ups and higher speed.

Application of the system's view

These general, structure determined, conclusions can be applied to the current situation in the oil tanker market.

As mentioned, the oil tanker market is presently in its 7th year of a period of overcapacity. Still, the equivalent of 40-50 million tons deadweight is absorbed in lay-ups and slow-steaming (out of a total fleet of 350 million tons dw). The next interval of scarce capacity will not begin until this overcapacity has been completely eliminated. This is unlikely to occur before 1982-3, and no soaring freight rates can be expected before then.

It is worthwhile to stress that I believe this conclusion is largely independent of the growth (or, more likely, decline) of seaborne oil transports over the next couple of years. The time of "balance" in the market is determined by the supply side, and will, roughly speaking, remain equally far in the future regardless of the rate of growth of demand. This is nothing but a restatement of conclusion 2 above: profitability is determined by supply, and supply will grow faster if demand grows faster. Opposite (and more likely), ships will be scrapped faster and new orders cancelled more frequently if the demand for oil transports softens even further.

Oil transport in the future

We have seen that the model can reproduce the past. And we have made statements about the future of the oil tanker market based on our understanding of the structure of the system. Let us now use the DYNAMO model to trace possible futures.

In order to run the model forwards, we need to make assumptions about the future development of the exogenous variables - primarily the determinants of the demand for oil transport.

To this end we undertook a detailed study of the global petroleum market (reported in GRS-214, see note 1). We split the world in 10 regions and studied oil production and oil consumption in each region. Same regions are net importers and other net exporters, and we assumed that the deficit regions ship in necessary oil from the nearest exporting region. Needless to say, the transport patterns can become complicated, and we used a linear program to establish the pattern involving minimal transport costs. Comparison with historical data proved that the solution of the LP was within 5-10% of the transport pattern actually used.

The LP solution can easily be converted to the inputs needed in the oil tanker model, namely global oil consumption, amount shipped and average transport distance. As production and consumption of oil change over time in the different regions, the LP solution will change and give time series for the same inputs.

Figure 7 shows the result of using this procedure to calculate likely developments to the year 2000. The figure is based on available statistics up through 1978 and model calculations from then on. We see that the total oil transport performed actually declines from 1976 to 1980. Then there is slow growth to a peak in the 1990's, followed by a new decline. The decline in the late 1970's is caused by the decrease in the transport distance which follows from the opening up of oil fields closer to the consumer nations. The decline in the 1990's is caused by beginning exhaustion of the world's petroleum reserves.

In the base case (solid line in figure 2) we assumed economic growth rates around 3%/year. (Corresponding to growth in oil consumption around 2%/year.) If we assume higher rates, the peak transport work occurs earlier, because the oil reserves are exploited faster. Lower economic growth stretches the era of oil transports. Possible extremes in the use of canals and pipelines to reduce shipping distances introduce about the same uncertainty in the projection as the variation in economic growth rates.

It is interesting to notice that the maximum transport work (around 15.000 billion ton-miles/year in the middle 1990's) is not larger than it could have been handled by <u>today's</u> fleet of oil tankers. The present overcapacity is significant, to say the least.

Model generated futures

Figure 7 shows the result of running the oil tanker model to 1990, from a new initialization in 1972, using the base case assumptions regarding the demand for oil transports (with a soft business cycle and a small amount of noise superimposed).

The result is as expected. The current period of overcapacity is over by 1983, and soon thereafter we see tendencies for rate increases whenever boom impulses hit the market, now having a high capacity utilization. But the period of acceptable freight rates does not last long before it triggers a new wave of optimism, cash and orders for more tonnage. As in 1974 and 1958 a wave of new ships stops the bonanza (in 1988).

It is worth pointing out that the bonanza occurs in a period of <u>declining</u> tonnage. The total fleet decreases steadily from 1979-1988, but this does not, of course, prevent high freight rates. In the tanker market profitability and volume are largely decoupled.

As a final curiosa it might be mentioned that figure 7 was made in February 1980, 1½ years ago. In the intervening period the real world events have deviated little from the model run.

<u>Alternative futures</u>

To test the sensitivity of the world, we made an experiment assuming an unrealistically high growth rate (7%/year from 1981-1990) in oil consumption. The result is shown in figure 8.

The market experiences a stronger boom than in the base case, but not at an earlier point in time. Because supply expands when demand does. The behaviour of the ship owners makes the system robust.

Like in all preceeding crises of overcapacity, the tanker industry is discussing a program of accelerated scrapping of old ships. Figure 9 shows the effect of removing from service each year twice the normal tonnage. The market recovers earlier, but the higher rates attract large investments in new ships, and by 1990 the market is once more on its way into a period of low rates and lay-ups. And no one has yet explained how one makes 1000 viciously competitive and individualistic shipowners agree on a program of scrapping.

<u>Postscript</u>

As can be seen from this paper, I view much of the development of the tanker market as determined by systematic behaviour in the shipping industry. Many will disagree and explain the events of the past 30 years as the result of a sequence of uncorrelated occurences.

The main insights to be gained from my perspective are described above. They add up to a belief that in our imperfect world - where people (including shipowners) do not easily collude or cooperate - the actions necessary to perturb the rhythmic development of the tanker market are so gargantuan that they will not be realized during the (relatively few) decades when oil will still be shipped.

NOTES

1. The main reports from the study are:

   1. Ulrich Golüke, Tanker Futures: A model of tanker market dynamics, GRS-141, April 1978, 90 pages.

   2. Ulrich Golüke, Four-Year and Twenty-Year Cycles in the Tanker Market, GRS-147, May 1978, 10 pages.

   3. Christoph Endress, The Demand for Tanker Transport up to Year 2000, GRS-214, June 1979, 124 pages.

   4. Per Axel Prydz, Lasse J. Franck, Ulrich Golüke, Bølger i tankfarten - Om tankmarkedets virkemåte og fremtid, GRS-284, April 1980, 88 pages.

   5. Lasse Franck, Per Axel Prydz, Waves in the Tanker Market (Technical Report), GRS-315, October 1980, 110 pages.

   All reports are available from The Resource Policy Group, Sagveien 21, Oslo 4, Norway.

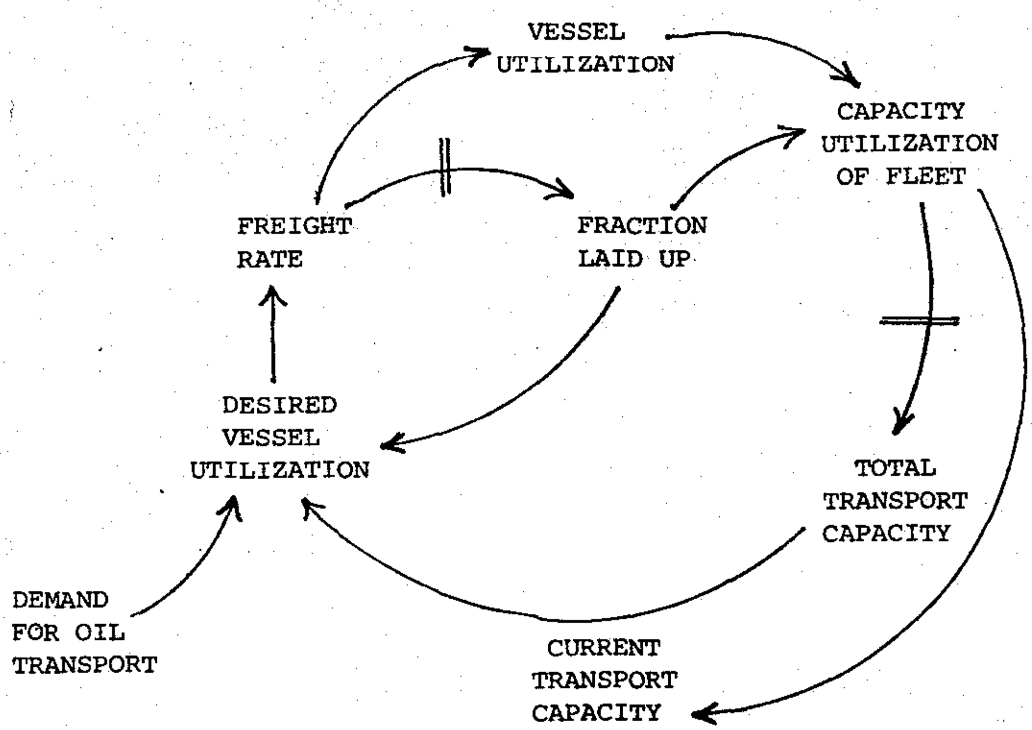
2. A ship of 100 000 tdw is capable of carrying approx. 100 000 tons of oil.

3. Actually, figure 1 exhibits a dimensionless index number called Worldscale. The Worldscale index is defined as the ratio between the freight rate (in \$/ton-mile) and a "standard" freight rate (in \$/ton-mile) which is adjusted continuously with inflation and technical developments in such a manner that Worldscale index 100 equals a rate which gives a reasonable return on investment in a tanker of 50 - 100 000 tdw. Bigger ships have lower cost per ton-mile and can operate with a profit at much lower Worldscale numbers.

4. We define vessel utilization (ton-miles/tdw- year) through

   $$\text{capacity utilization} = (1-\text{fraction laid up}) \times \frac{\text{vessel utilization}}{\text{designed vessel utilization}}$$

   Designed vessel utilization (ton-miles/tdw-year) is the amount of transport work that can be done per ton deadweight each year assuming normal speed, harbor times, maintenance etc. Figure 6 seems to imply a one-to-one correspondance between the freight rate and capacity utilization. This is incorrect, both in the model and reality, and simply a consequence of simplification. The real structure is shown below and is capable of recreating the main characteristic of the recurring 10 year depression, namely gradual increases in the capacity utilization as ships come out of lay-up while the freight rate remains essentially constant.



5. See figure 9 and Appendix B in GRS-284 for a heroic effort to construct a 20 year time series for the capacity utilization.

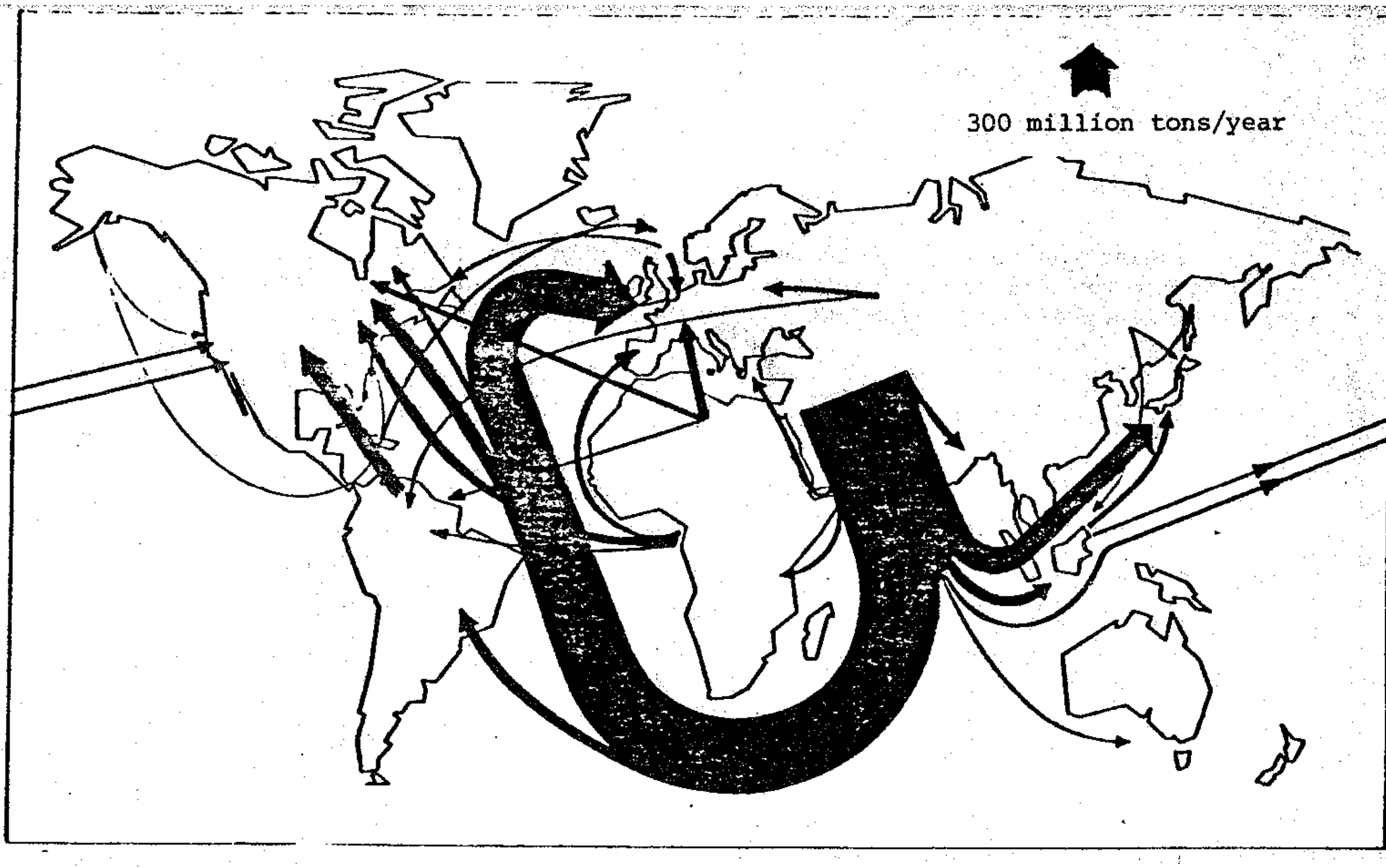


Figure 1. Pattern of ocean-borne oil transports in 1978.

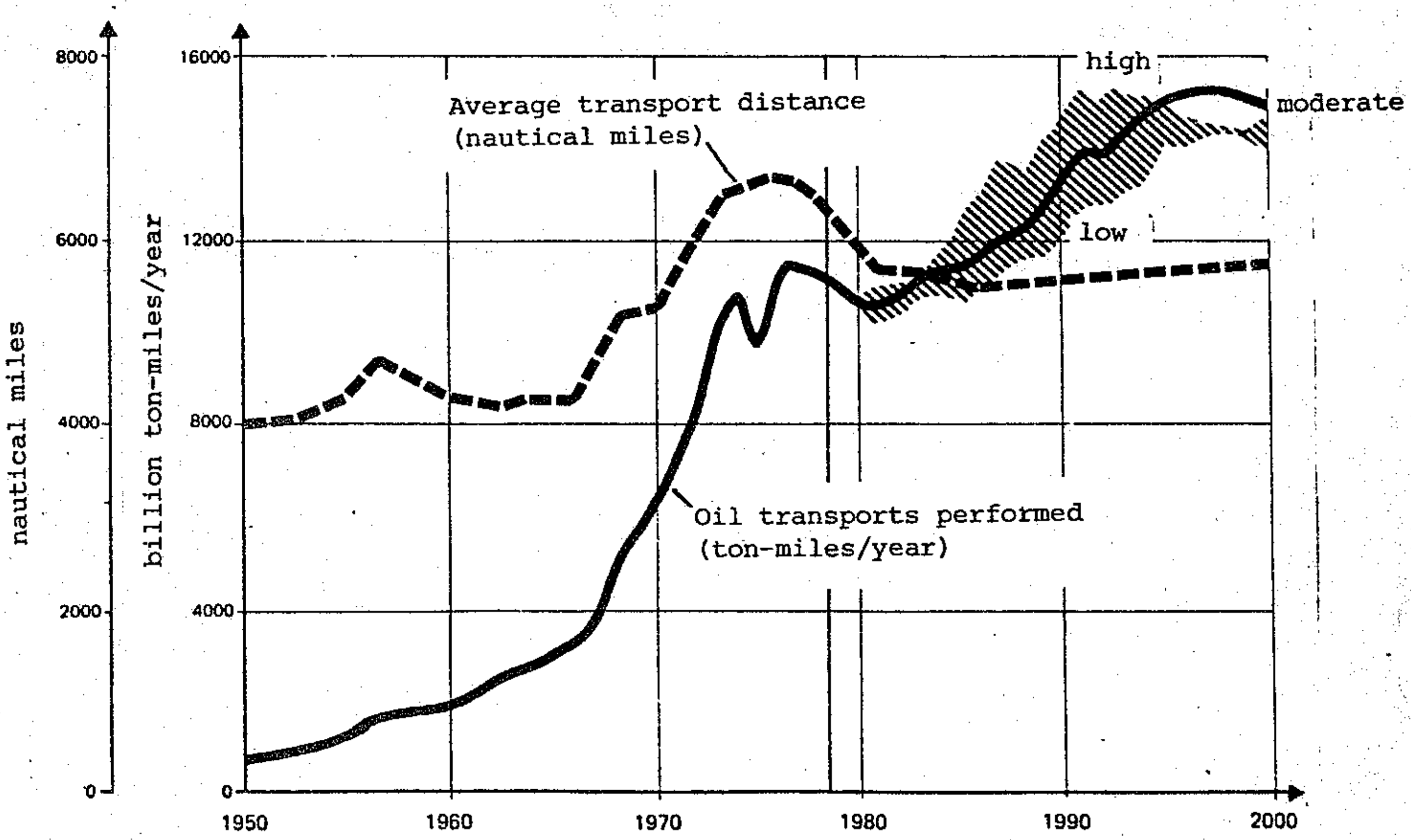


Figure 2. Global oil transports: historical development (1950 - 78) and model calculation (1978 - 2000) for moderate, high and low economic growth rates.

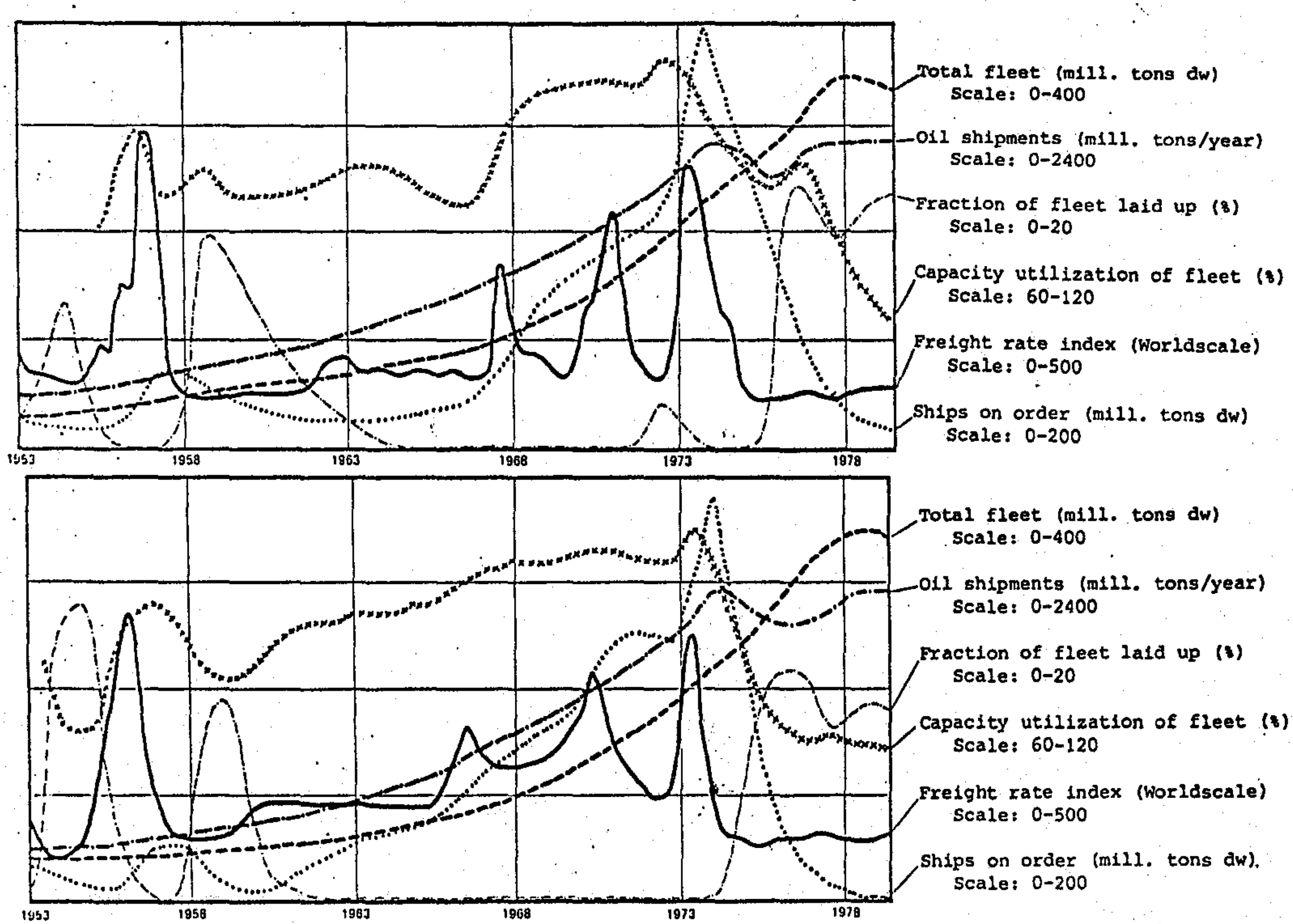


Figure 33. Historical (top) and simulated model (bottom) behaviour.

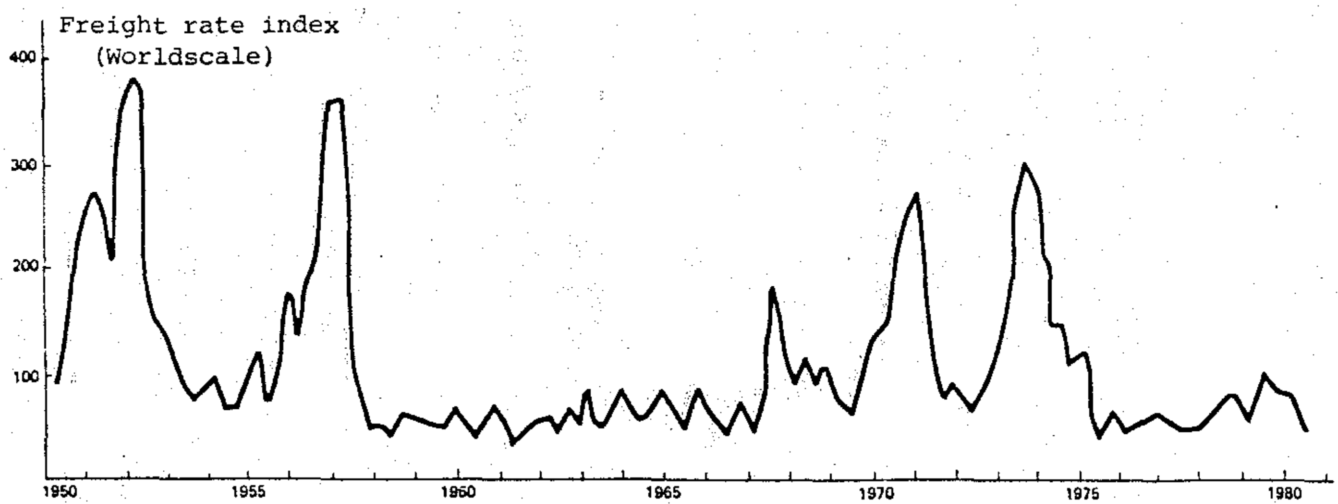
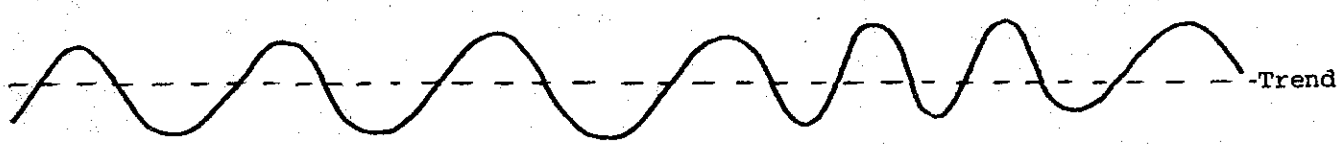
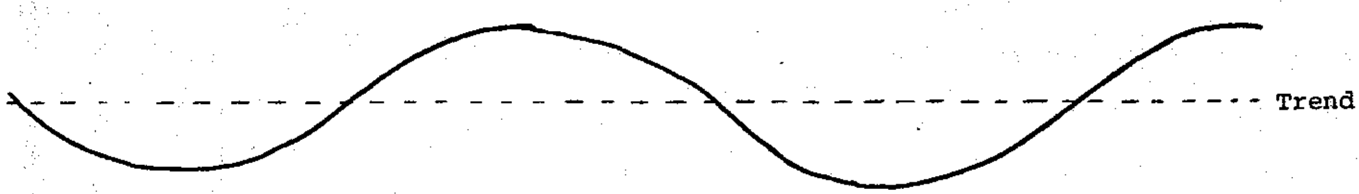


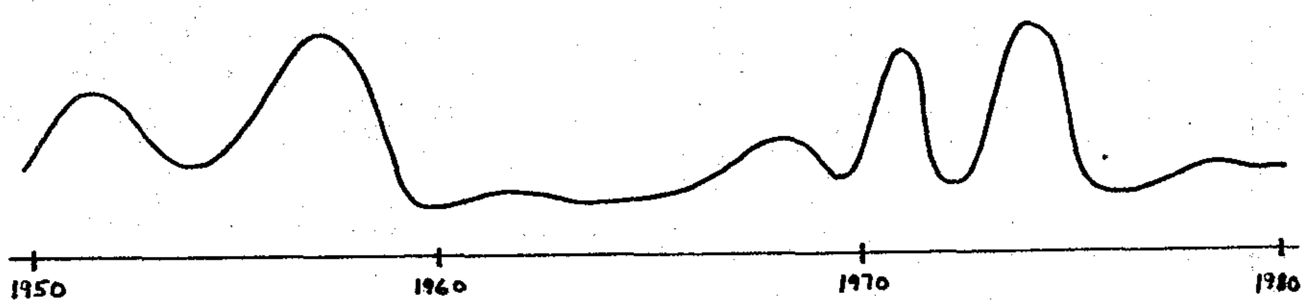
Figure 4. The Worldscale Index for oil tanker freight rates, 1950-80.
Worldscale=(current rate in $/ton-mile)/("normal" rate in $/ton-mile).



a) 4-year business cycle in the demand for oil transport



b) 20-year investment wave in the supply of oil tankers



c) Resulting pattern in the freight rate.

Figure 5. The effect on the development of the freight rate of the interaction between a 4-year wave in demand and a 20-

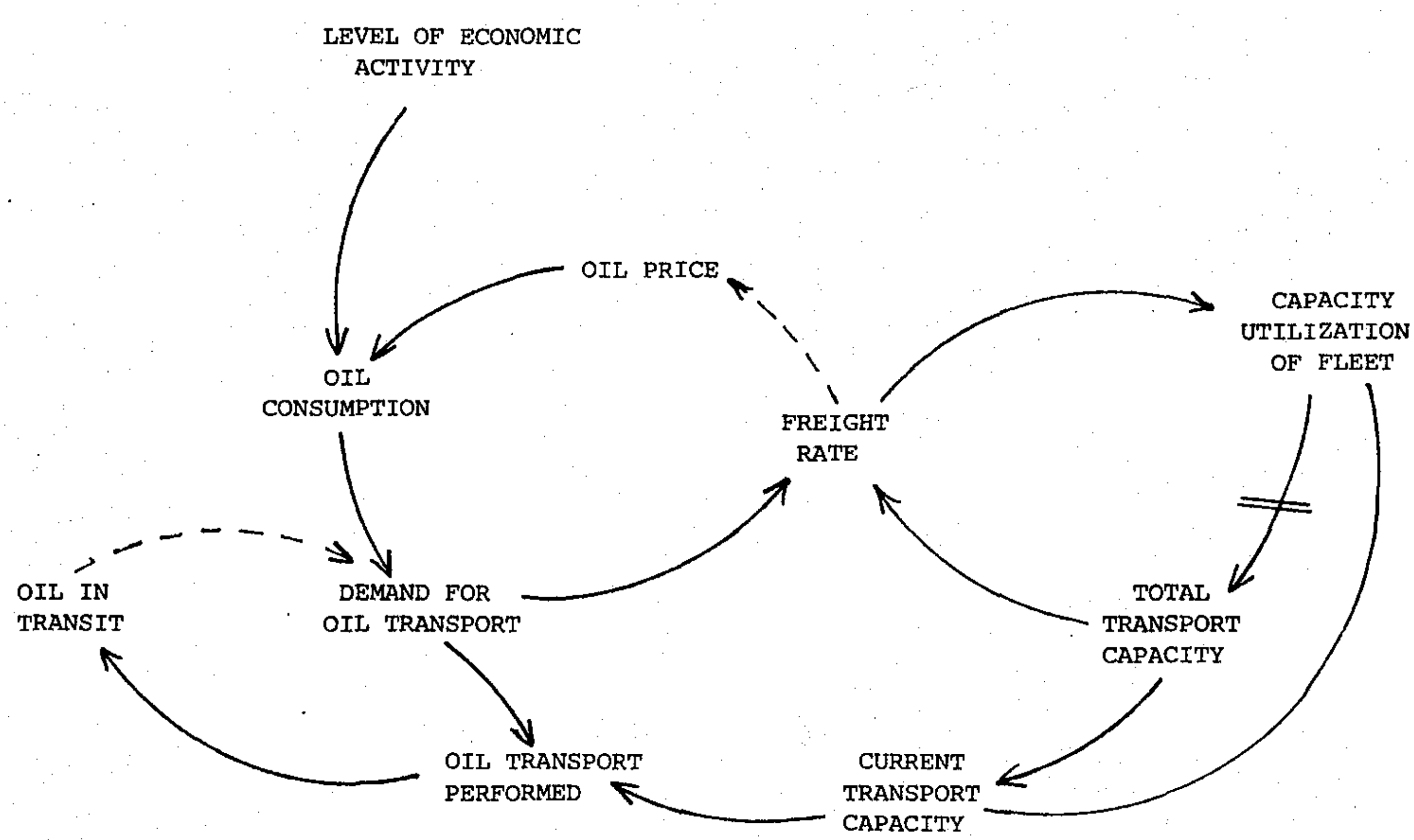


Figure 6. Basic structure of our model of the market for oil tankers.

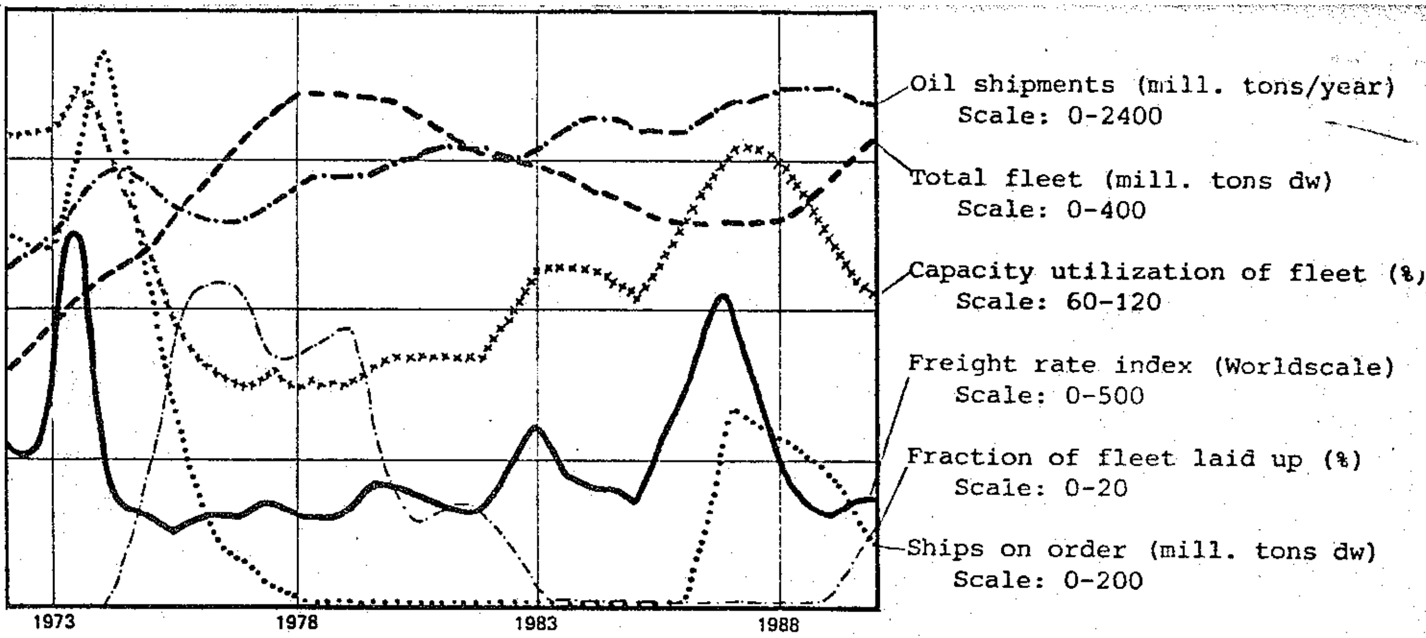


Figure 7. Run assuming 2 %/year growth in oil consumption.

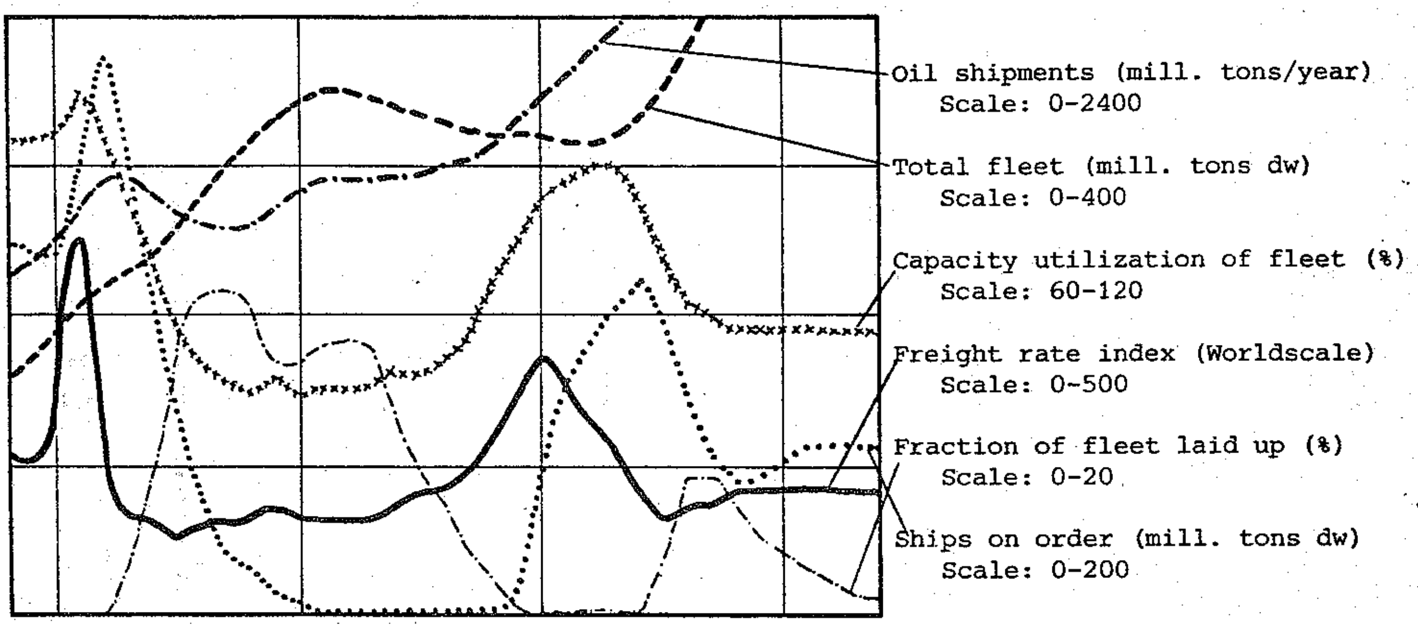


Figure 8. Run assuming 7 %/year growth in oil consumption.

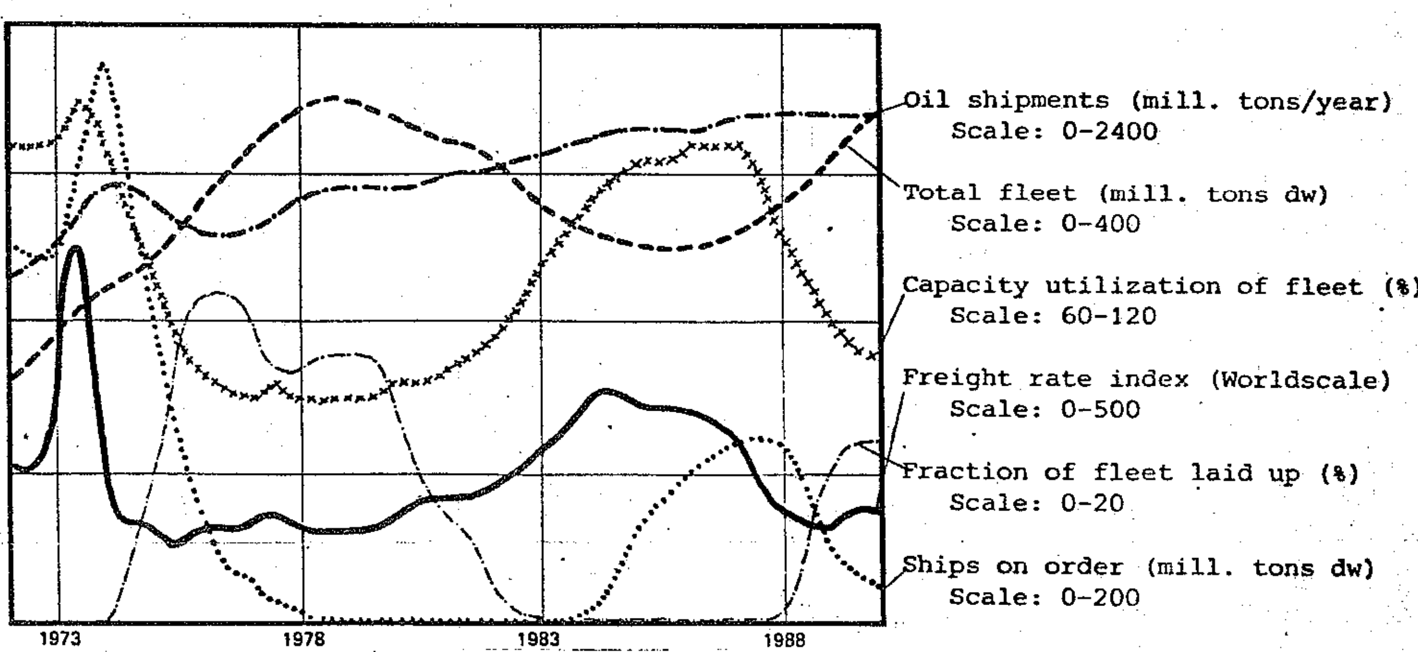


Figure 9. Run assuming double scrapping rates.