# Forecasting turning points in shipping freight rates: lessons from 30 years of practical effort

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*Abstract*

We argue that it is possible to explain much of the history of the world's shipping markets since 1950 as the interaction of two balancing feedback loops: a capacity adjustment loop which creates a roughly 20-year wave, and a capacity utilization adjustment loop which generates a roughly 4-year cycle. We show how this insight has been used rather successfully since the early 1980s for practical forecasting of turning points in freight rates and the "sentiment" in the shipping market 1–4 years ahead of time. The basic mechanisms in the shipping system create a strong "deterministic backbone" which is visible through the exogenous noise, and hence predictable with useful precision. Our experience leads to a number of questions concerning system dynamics best practice for future research. Copyright © 2007 John Wiley & Sons, Ltd.

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## Introduction

### *The dynamic hypothesis*

This paper reports on the main results of our (part-time) effort over the last 30 years to study the global shipping markets using system dynamics. Over these decades, we have built several system dynamics models to study the development over time in shipping freight rates, i.e., in the cost of transporting something from A to B by ship. There are many freight rates: for different cargoes, different vessels, and different contract types.[1] But these different freight rates are surprisingly strongly correlated over time, when seen in a multi-year perspective. This is mainly because of the strong degree of substitutability of cargoes among vessels across routes: most cargoes can be transported on a number of different ships, so conditions spread quickly from trade to trade. Secondly, investors and financial institutions are undifferentiated as to specific trades and thus provide additional substitutability. Hence it is meaningful to talk about the shipping market as one entity: things are "good" or "bad" more or less in parallel throughout the global shipping market. There is in fact a common "market sentiment", which can be described as the level of optimism amongst all market participants, typically reflecting the level of current freight rates. The time variation of this generalized freight rate is our topic of study, on a time horizon of 1–4 years.

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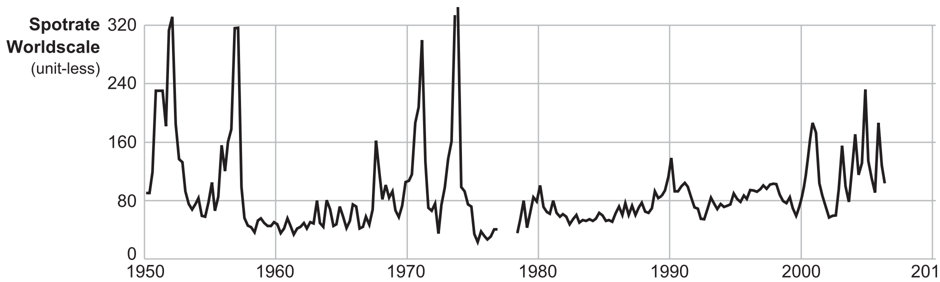


Fig. 1. Spot freight rates for very large carriers (VLCCs) from 1950 to 2006—the reference mode of our study. Source: Hageler (1977); *Lloyds Shipping Economist* (various issues); *Drewry Shipping Statistics* (various issues) as described in Goluke (2006)

Most of our modelling work was done in cooperation with people from the shipping industry. During the first 4 years of our effort, we worked largely to understand the sector, or more precisely to "test our dynamic hypothesis" (Randers, 1980). Our dynamic hypothesis has remained our unwavering and immensely helpful guiding star during three decades of work, supporting the recommendation of Campbell (2001, p. 200). It states that the time pattern of shipping freight rates is dominated by the workings of two feedback loops, which govern fleet size (capacity) and fleet utilization (capacity utilization) respectively, in a manner well known to most system dynamicists. This time pattern is shown in Figure 1, which constitutes the reference mode of our study.

After 1980 our prime motivators have been a handful of senior decision makers in the shipping industry who have continuously wished for reliable predictions of market developments over the next 1–4 years to guide their ordering of new ships and decisions on use of their current fleet.

Over the years, we have accumulated much support for our dynamic hypothesis—enough to argue that our "endogenous" perspective on global shipping is useful, both academically and for shipping practitioners. Furthermore, we did ultimately find a way to convert our dynamic hypothesis into useful forecasts for our senior clients. But that took a long time, perhaps 13 years to the first commercial success. In retrospect, it is clear that we have implicitly been pursuing the traditional goal of system dynamicists: namely to shift the entire worldview of our clients, from a short-term, event-oriented, exogenous-forces view to a long-term, dynamic, endogenous view, which places much of the blame for the famous booms and busts in shipping on the industry itself. We have made some progress on this bigger agenda, influencing the thinking of our clients. But it seems that our willingness to provide forecasts had a much stronger impact on our clients' behaviour.

We estimate that the effort has cost a total of U.S. $700,000 (in 2006 money), or some 7 man-years. A Norwegian research council paid the initial $200,000 in 1977–1980; a governmental risk loan provided around $150,000 in 1985; while private ship owners provided more than $350,000 from 1980 through 2006.

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Our effort remained part time both because we had other jobs and because funding for full-time work never emerged, in turn perhaps as a consequence of our slow progress. But the fact that our work was spread over many years is not essential. The actual way followed, and the chronological time used, can be seen from the complete chronology of project reports presented in the Appendix (available at www.futuremappers.com).

*The global shipping market*

The global market for oil tankers consists of special-purpose oil tankers that carry crude oil on long hauls from oil-producing to oil-consuming nations; for example, 300,000 tons of crude from Saudi Arabia to the U.S.A. It includes the somewhat smaller product tankers that transport refined oil products like heating oil and gasoline over shorter distances; for example, 20,000 tons of fuel from Rotterdam to another European port—plus a handful of combination vessels, which can transport both oil and dry cargo.

The oil tanker market[2] consists of some 3000 vessels owned by some 1000 independent owners, transporting 2.5 million tons of crude oil and oil products per year, on a large number of different routes ("trades") from producing areas to consuming areas. The tankers vary in size (from 1000 to 450,000 tdw), as do the ship-owning companies (controlling from one to 500+ ships each). Trips last from 2 to 40 days, and ship technology differs (motors or turbines, single or double hulls, ballast water treatment or not, etc). The owners work under conventions of the high seas and rules agreed by the International Maritime Organization, and many others concerning allowable technology and operational procedures (emissions, handling of ballast water, frequency of inspection, etc.). Many nations apply strict rules concerning the type of ship they will allow in their ports. Most ships are registered in countries that offer attractive taxation levels and allow the hiring of low-cost sailors.

The decisions to buy or sell vessels, and to allocate available ships among trades, on long or short contracts, are dominated by unbridled competition, within the existing rules. This competitive environment applies both to the traditional ship owner who invests in ships to use them for a long life of industrial shipping in close cooperation with the owner of the cargo, as well as to the short-term asset player who buys and sells ships for the formidable profit that can be had in months or quarters if one's timing is good. It certainly is an attraction, both for businessmen and academics, that the global shipping market—and especially the oil tanker market—is a readily available case of pure capitalistic competition. Here market forces have been in full, brutal and open play for a century and more. It is important that freight rates can vary enormously (by a factor of 10 or more in spot markets) because the transport cost is a tiny fraction of the value of the cargo (never reaching 5%).

The history of the tanker market since 1950 is illustrated in Figure 2.

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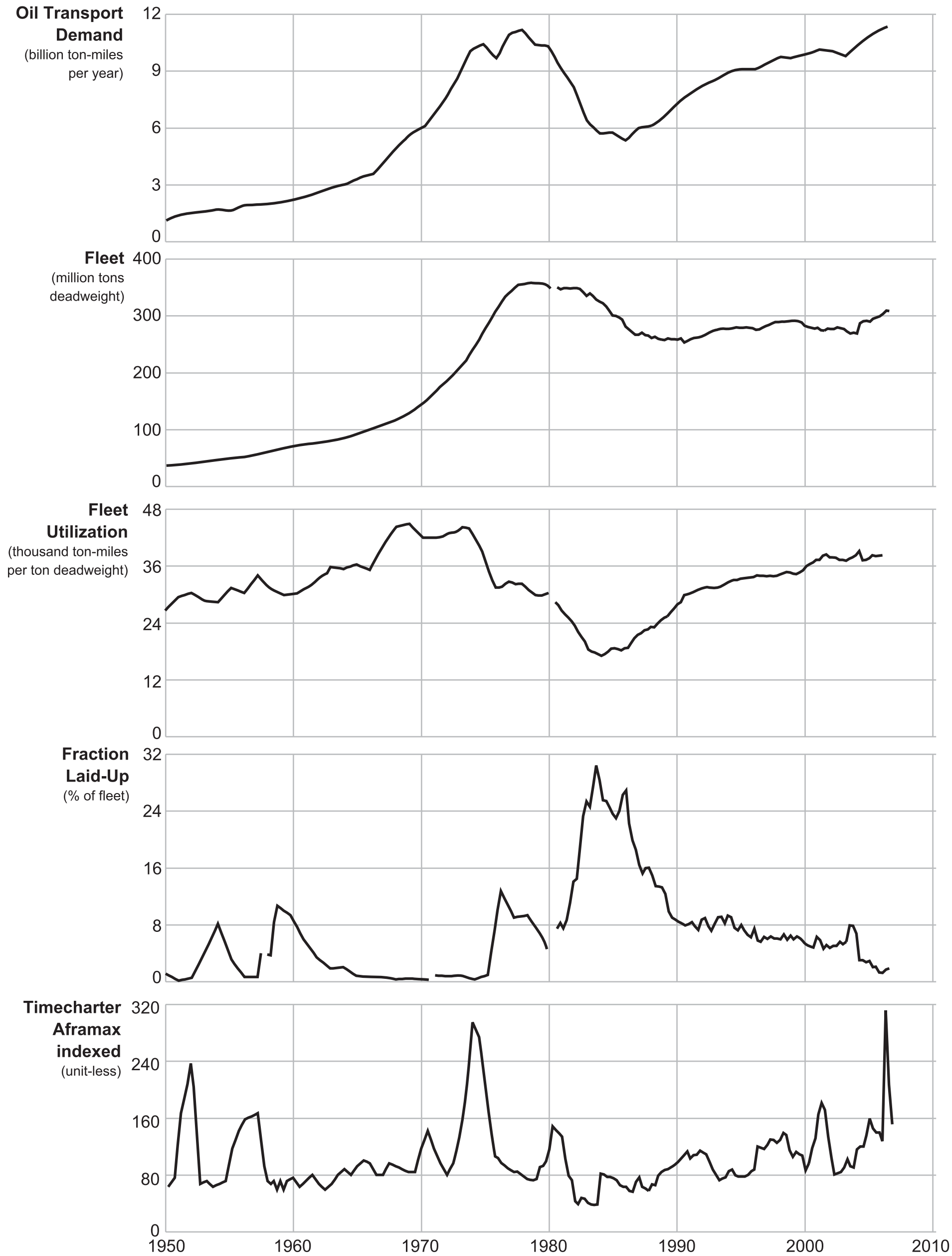


Fig. 2. Historical development of the oil tanker market from 1950 to 2006. Source: Hageler (1977); *Lloyds Shipping Economist* (various issues); *Drewry Shipping Statistics* (various issues) as described in Goluke (2006)

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## Modelling the shipping market

*It is crucial to have a dynamic hypothesis as a guiding star*

The starting point of our effort, in 1976, was a sudden insight arising when Randers saw a plot of (spot) freight rates for oil tankers from 1950 to 1975 (the left-hand part of Figure 1) and immediately recognized the well-known pattern of interplay between a "4-year" capacity utilization cycle and a "20-year" capacity adjustment wave—well known to any system dynamicist at the time, some years after the publication of two books on this behaviour mode in other contexts: commodities (Meadows, 1970) and the national economy (Mass, 1975).

The seemingly erratic pattern of oil tanker freight rates in Figure 1 became the reference mode of our study: a "4-year" cycle superimposed on a "20-year" wave, in addition to a lot of noise. The "4-year" cycle is seen as the consequence of ship owners' attempt to optimize the use of their *current* fleet given *current* market conditions—for instance, by adjusting vessel speed, lay-up and loading fraction. The "20-year" wave is seen as the result of ship owners' tendency to order too many new vessels when the shipping market is good—that is, when shipping rates have been high for a long time—and ordering far less when the market is bad. The quotation marks around the average length of the two fluctuations are meant to remind the reader that the exact wavelength of both fluctuations varies by at least ±20%, due to noise in the market.

THE REFERENCE MODE The reference mode was described repeatedly in our early work (Randers, 1977, 1981, 1984). The 4-year cycle and the 20-year wave interact, to form the complex pattern illustrated by Figures 1 and 2, as follows.

The 20-year wave is a fluctuation between periods of over-capacity (i.e., too many ships relative to current demand, and hence lower rates) and periods of under-capacity (i.e., too few ships, and hence higher rates), each period lasting a decade or so. Significantly and logically, when there are too many ships, rates tend to stabilize at a low level, just above the "refusal rate" (i.e., the lowest rate at which an owner prefers to operate his or her ship rather than having it in lay-up). The rate cannot fall much lower, because if it did all vessels would be laid up. So when—in one of these periods of low rates—demand picks up, and rates start to rise above the minimum level, additional ships are quickly (in 1–6 months) taken out of lay-up. The extra supply pushes the shipping rate back toward the refusal level, where it remains, hovering just above the refusal rate until all vessels are out of lay-up. This state of affair lasts a long time (a decade or so), both logically and empirically, given that one may have a full 20% or more of the fleet in lay-up at the onset of a period of over-capacity. It is only once all vessels are out of lay-up that rates can increase significantly, and make more intense utilization of the fleet profitable. Thus, there is little sign of the 4-year cycle in freight rates during the decade of

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over-capacity. At most, the 4-year cycle can be glimpsed as a soft undulation in fleet utilization. But the gradual decline in "fraction laid-up" is easily observed (see Figure 2); and during such periods of over-capacity there is no desire to order new ships. Instead, there is a tendency to scrap ships to save the cost of continued lay-up.

The situation is different during the decade-long periods of under-capacity, when there are too few vessels to cover demand with *normal* usage of the fleet. Then all ships are already running and, if demand and rates increase, the only way to expand supply is through increased utilization of the fleet. Owners increase the speed of their ships, encourage fuller cargoes, shorten the time in port, postpone maintenance stops, choose more expensive, but shorter, routes (e.g., through canals) and so on. This behaviour is at the root of the 4-year cycle. There is great potential for productivity increases: a vessel can easily perform 50% more work in a year than it does when it operates near the refusal rate, when measured in ton-miles per ton-deadweight per year (Randers, 1984, p. 53). Normally, the ship owner will implement the cheap and simple improvements first. Once they are exhausted, and demand is still not fully met, rates will continue to rise as a consequence, and make yet further productivity increase profitable. At the end, when rates have reached very high levels and all ships are moving at high speed, ship owners start coordinating shipping patterns with competitors, to get as much transport work out of the entire fleet as possible. At the same time they order new ships. At first, orders rise in a rational manner, just enough to handle likely demand. But when rates continue to rise, making shipping amazingly profitable, all inhibitions are finally cast aside, and ships are ordered as long as yards accept new orders and banks provide finance. When all vessels are already in full use, owners can do nothing but wait for new tonnage to be delivered. Meanwhile, rates soar. They can go very high because the cost of transport is so low (from U.S. $1 to $3 per barrel from Saudi Arabia to the U.S.A.) compared to the value of the cargo (from $20 to $60 per barrel), and because there is no alternative to transport by sea.

The basic mechanisms Thus we argue that the reference mode is created by the interaction of a "capacity utilization loop" creating the 4-year cycle, and a "capacity adjustment loop" generating the 20-year wave. The two interacting loops constitute our basic mechanisms, and are shown in the causal diagram in Figure 3.[3] A simple system dynamics model incorporating these two loops is shown in Figure 4.

The simple structure in Figure 3 is readily accepted by shipping practitioners as a rough description of the oil tanker market. The capacity adjustment or "investment" loop is a normal part of the mental model of most people in shipping. The capacity utilization or "ship productivity" loop, on the other hand, requires more explanation, but is accepted once explained. In both cases practitioners do believe that the delays around the loops are shorter than appear to be the case when testing the full model against history. Notice that

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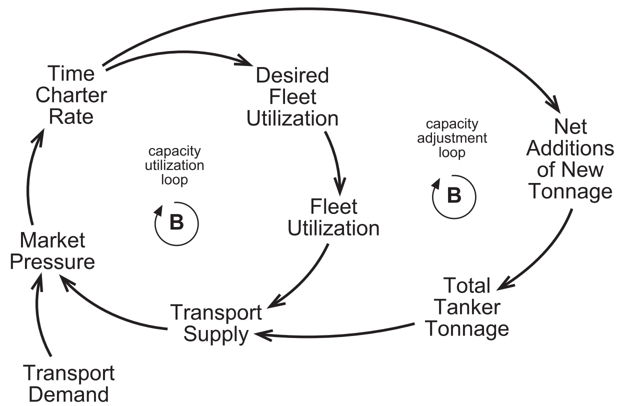


Fig. 3. The basic mechanisms of our study. The mechanisms are described in Randers and Goluke (2002)

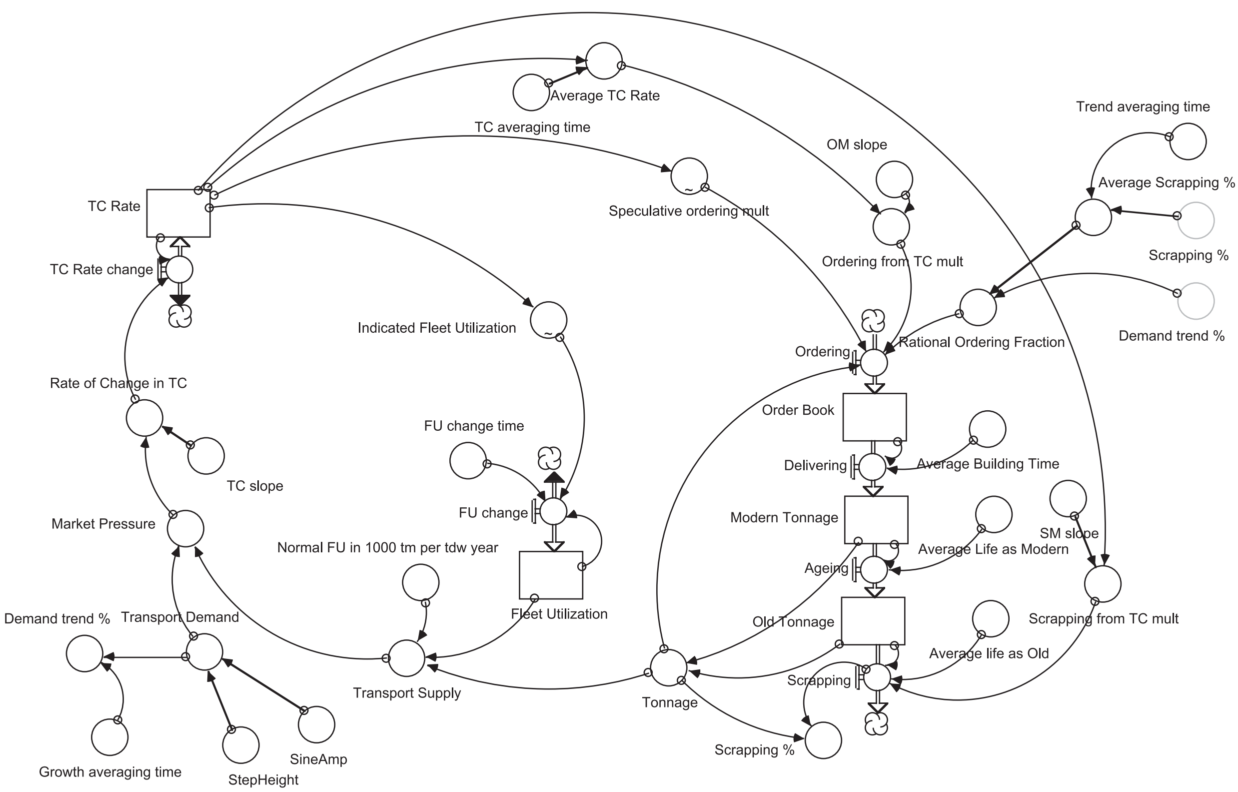


Fig. 4. The simple model we use for forecasting. Source: www.futuremappers.com/Figure4-SimpleModel2003.stm.zip

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there is no feedback in Figure 3 from freight rates (Time Charter Rate) to demand for transport (Transport Demand). This may surprise outsiders, but is readily accepted by the shipping community. They know that the cost of shipping oil is minuscule compared to the value of the product: shipping costs amount to a few cents per gallon of gas at the pump. Even big swings in the freight rate have no measurable effect on demand. Furthermore, it helps acceptance that most of the causal links in Figure 3 are included in standard econometric models of the oil tanker market (e.g., Norman and Wergeland, 1981; Marsoft, 2007). But, importantly, the conventional econometric models do not normally close the two major loops, and hence they do not capture our reference mode.

Tests of the dynamic hypothesis In summary, our dynamic hypothesis is that the two balancing loops in Figure 3 interact to form the reference mode in freight rates in Figure 1. In the first several years of our study, we tested the dynamic hypothesis according to best system dynamics practice (collecting time series and anecdotal data, evaluating the plausibility of the structure, discussing with practitioners, using industry people to work on the model, recreating the reference mode, reproducing history and so on (Coyle and Excelby, 2000) and found much support for our hypothesis in individual trades and in the market as a whole. We learned from those years that the submarkets of the shipping markets are so tightly entrained that it is possible to describe the market as one entity—at least when the time horizon is a year or more. It is not necessary to disaggregate the model into submarkets for the study of the reference mode. Our dynamic hypothesis can be stated at the level of the entire oil tanker market and has served as an invaluable guide through decades of modelling work. It treats all tankers as one fleet, irrespective of size, trade or technology, and has helped us from drowning in a sea of detail.

The simple model in Figure 4 can indeed recreate the essence of the reference mode, as shown in Figure 5, when started in equilibrium. A step input triggers the 4-year cycle and also a 20-year wave, but both oscillations are damped when using parameter values that are carefully chosen to match the real world. This damping makes it difficult to trigger the spectacular reference mode shown in Figure 1. It does help, however, to drive the model with a 4-year cycle in demand.

The need to drive the simple model with a 4-year cycle in demand to create the reference mode raises the question of whether the observed shipping cycles are in fact endogenous or exogenous. Most shipping practitioners would argue that the 4-year cycle—if it does indeed exist—is caused by the general business cycle of the same wavelength (3–6 years), reflected in transport demand. Our view is that there is a strong endogenous tendency for a 4-year cycle in shipping, and that this cycle is amplified by (resonates with) any 4-year component in transport demand (Goluke, 1983). Visual inspection does not reveal a 4-year component in transport demand statistics, and we have not

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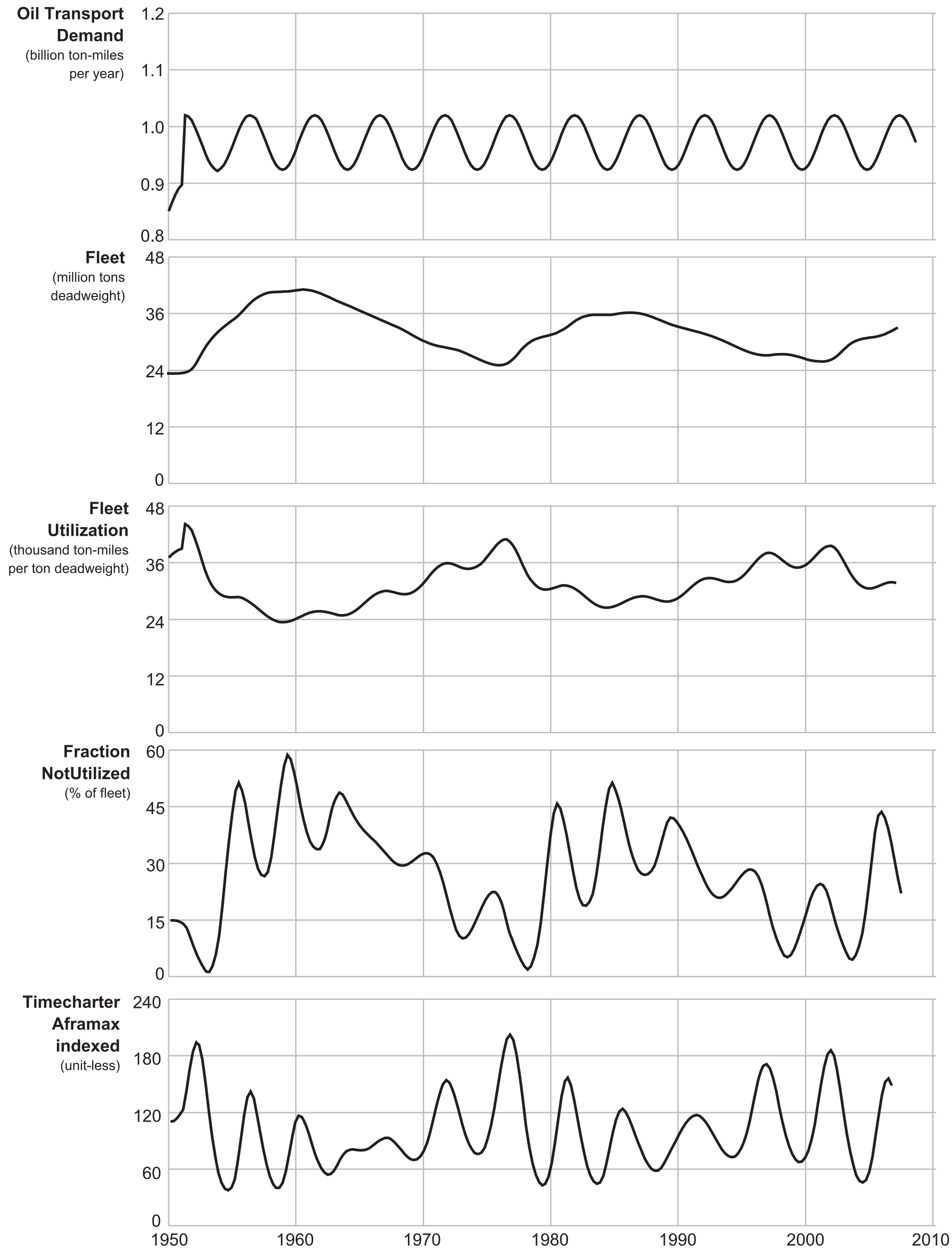


Fig. 5. Creating the reference mode with the simple model and a sinusoidal driver (6%) and a step input (15%). Source: www.futuremappers.com/Figure5-SimpleModel2003.stm.zip. "Fraction Not Utilized" is used as proxy for "Fraction Laid Up"

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done spectral analysis to investigate further. But one would expect the 4-year component to be there, as a result of the pervasive influence of the business cycle. At any rate, the simple model recreates the reference mode when driven by a 4-year cycle (with an amplitude of 5% or more). But the alternative, fully exogenous, explanation cannot be completely ruled out, and the issue warrants further research, in the tradition of Mosekilde *et al.* (1993).

The frequency and stability of the two cycles depend on the parameter values used in the simple model. They are few: 11 constants and two table function slopes (see www.futuremappers.com/Figure4-5simplemodel2003.stm.zip). We have combined many techniques to arrive at our final choice of parameter values: for instance, physical data from the shipping world, practitioner judgement, estimated slopes from econometric studies, tests to ensure that scatter diagrams of synthetic data from model fit scatter diagrams of real-world data, and the ability of the full system to recreate the reference mode. By (informal) testing of the sensitivity of the length and amplitude of the 4-year cycle and 20-year wave to parameter variations, we have concluded that our conclusions are fairly robust. But one does need surprisingly long delays between freight rates and ordering (4-year, third-order delay) and between freight rates and utilization (2-year, first-order delay) to make the simple model fit available data.

We conclude that the basic mechanisms are capable of generating the reference mode, supporting our dynamic hypothesis.

EARLIER LITERATURE The dynamic hypothesis was first proposed in 1977 (Randers, 1977) and then further explored by us and our colleagues in the Resource Policy Group in Oslo during the following years (Goluke, 1978c, 1978d; Franck and Prydz, 1979d, 1980b; Prydz *et al.*, 1980; Randers, 1981). The dynamic hypothesis was extensively described in (Randers, 1984), which also pointed to the older literature on the observed fluctuations in the shipping markets (Koopmans, 1939; Zannetos, 1966). Independently, Michael Hampton proposed the same capacity adjustment mechanism for the 20-year wave in the late 1980s (Hampton, 1989), but he thought the wave was shorter, and furthermore did not identify the 4-year cycle as a separate phenomenon, with an endogenous cause. Thus no one seems to have pursued the dynamic hypothesis of interacting 4-year cycles and 20-year waves in shipping, beyond a general mention of the hypothesis by Sterman (2000, p. 796). Interestingly, even a study of shipping dynamics performed in the system dynamics tradition disregarded the 4-year cycle for the benefit of the 20-year wave (Bakken, 1993). Finally, Taylor described much of the relevant causal structure in two system dynamics papers (Taylor, 1976, 1982), but his remained a collection of links, because he lacked the organizing force of a dynamic hypothesis. As an example, Taylor assumed an exogenous freight rate, independent of supply and demand for transport. The traditional econometric way of modelling shipping freight rates is presented well in Wijnolst and Wergeland (1997).

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*It is possible to recreate much of the history of the oil tanker market using a very simple model*

Recreating history   If we initialize the simple model to reflect conditions in 1950 and then drive it with annual data for the demand for oil transport from 1950 to 2005, we achieve a relatively good match to history for the system levels (i.e., fleet size and fleet utilization). But annual data for demand does not recreate the spectacular volatility in historical freight rates. This volatility can be reproduced by adding a mild 4-year cycle to annual demand. Doing so, we can make the simple model recreate the essential aspects of shipping history from 1950 (see Figure 6). Timings and amplitudes are far from exact, but sufficiently close to indicate that a good match is achievable through inclusion of additional model structure.

It is actually quite impressive that a few equations and only one time-varying driver—namely annualized transport demand (in ton-miles per year)—are capable of recreating the essence of half a century of shipping history.

This conclusion is supported by using a more elaborate model. As an example, Figure 7 shows the output from a bigger model (Franck and Prydz, 1980b), which contains some 300 lines of Stella code, compared to 60 in the simple model. This bigger model contains more detailed descriptions of the ordering of new ships, the ship construction delay, the lay-up and utilization decisions, the allocation of ships between spot and time-charter markets, and oil demand dynamics. When work was done in 1980 with the model initialized in 1953, it did recreate history until 1980 quite well.

Conclusion   The simple model in Figure 4 is capable of generating the reference mode and also capable of recreating the essence of historical developments over a very long time period, with very little exogenous input. Thus we conclude that much of the observed time development in the oil tanker market is indeed caused by the two interacting feedback loops in Figure 3. Clearly there is noise, but the noise rides on the back of a rather robust "deterministic backbone" generated by our basic mechanisms of two interacting feedback loops. The deterministic backbone is our label for what Lyneis (2000) calls "structural momentum". Thus, using his words, we believe the oil tanker market is characterized by significant structural momentum.

This stable, deterministic backbone is a useful and necessary starting point when trying to forecast developments in the oil tanker market on a 1- to 4-year horizon. Interestingly, we have not been able to find similar stability in short-term shipping dynamics. Shipping phenomena on a shorter time scale than 2 years appear to be dominated by noise. The only exception is the rather regular *annual* cycle caused by the extra demand for oil in the second and third quarters in preparation for the northern winter.

The model also explains the recent "depression" in shipping, namely the 1978–2000 period of over-capacity and low freight rates. Normally the 20-year

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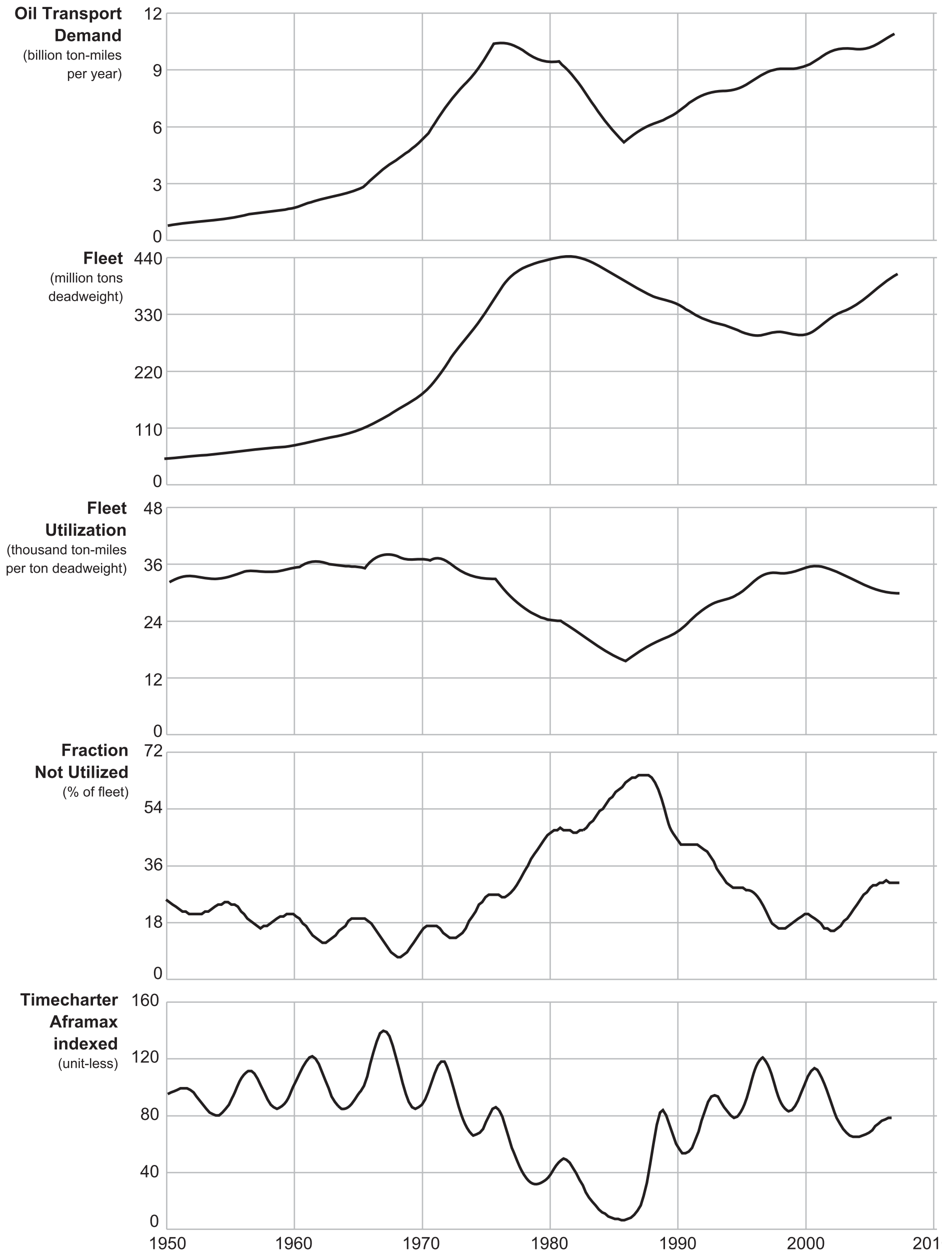
Fig. 6. The simple model is capable of creating the rough elements (e.g. high utilization in 1970 and 2000) when driven by a smoothed historical demand and a sinusoidal input (±2%). Source: www.futuremappers.com/Figure6-SimpleModel2003.stm.zip

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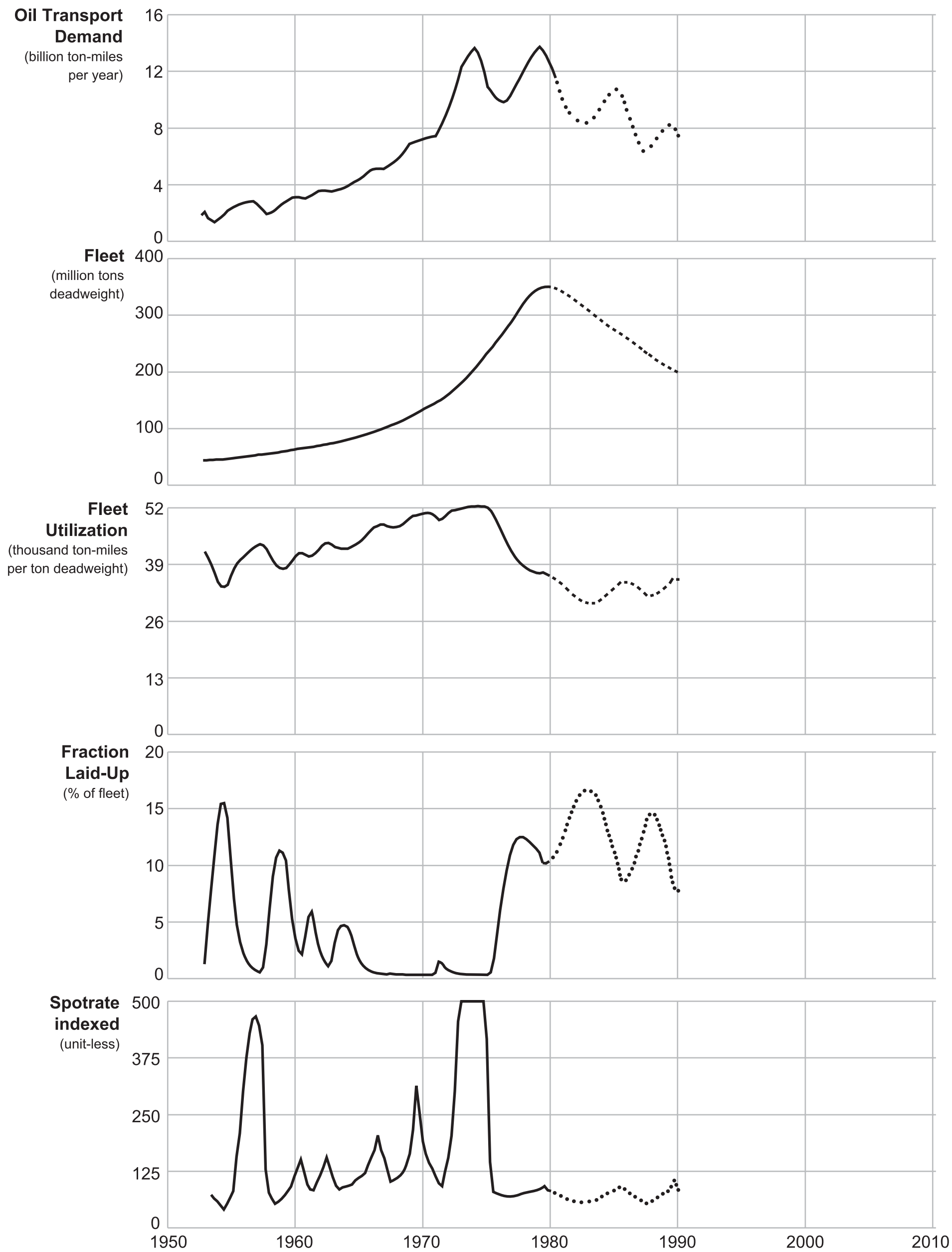


Fig. 7. In 1980 we ran a complex model from 1953 out to 1990. It recreated history until 1980, and forecast the disastrous 1980s rather well. History, solid line; forecast, dashed line. Source: www.futuremappers.com/Figure7-BigModel1980.stm.zip (Franck and Prydz, 1980b)

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wave would include a 10-year period of over-capacity. The 1978–2000 downturn lasted twice as long. The explanation is the dramatic fall in oil transport demand—by 50% from 1978 to 1986 (see Figure 2). This exogenous shock was sufficiently big to overwhelm the normal capacity of the ship owners to keep the downturn to 10 years only. They could not reduce the fleet quickly enough, and got stuck with low rates for more than two decades. But the downturn did finally come to an end, just after the year 2000.

### *Much of the volatility of the oil tanker market is created by the shipping community itself*

Shipping practitioners typically hold the view that the cyclicality and volatility of their own industry have exogenous causes—arising primarily from the economy outside the shipping world. They do not share our view that the changing conditions in shipping are largely the endogenous result of their own actions. And they do not normally acknowledge the cyclicality (regularity), only the volatility. But there are exceptions, as for example the story told by the famous Norwegian ship owner Erling Næss in his autobiography (Næss, 1977).

Challenging the conventional wisdom  Conventional shipping practitioners, academics and analysts all argue that the challenge of never-ending turbulence in global shipping is largely due to events outside the shipping sector (like conflicts and war, canal closings, interest hikes, bunker price changes, legislative change) which impact on the demand for transport of oil. For an example, see Stopford (2000, p. 58).

In our view ship owners contribute to their own difficulties. The shipping community creates the cyclicality and adds significantly to the volatility of their business environment through their own investment and allocation decisions. We call this perspective the "self-infliction view".

The self-infliction view is resisted for many reasons. First, most insiders simply do not believe it is true. Second, it emphasizes the fact that if the shipping community acted rationally on the abundantly available information (on ordering, scrapping, utilization and so on) they could greatly reduce the violent volatility that makes their daily life so difficult. Thirdly, some players oppose the idea that the volatility is in fact systematic. They prefer the volatility to be random, because they think it makes it easier to make fortunes in shipping.

### *It may be an advantage to seek the simplest model*

Simplification as an ideal  In many system dynamics efforts, there is a tendency for the model to grow in size and complexity. As a consequence the model builder often loses control over his or her own model, and may no longer know what is the core structure responsible for the model's behaviour

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(see Randers, 1973, for a well-documented case). Several formal methods have been suggested over the years to overcome this problem (Richardson, 1986; Oliva and Mojtahedzadeh, 2004). But when such simplification methods are not used, the model often becomes a "black box", generating output which has to be interpreted through laborious and time-consuming experimentation—often with a less than satisfactory result.

We chose a different route: like Barlas and Saysel (2006), we continued our search for the simplest possible model—still capable of generating the reference mode and recreating the broad sweep of shipping history over several decades. We deemed this to be an interesting scientific ambition, and also tacitly assumed that a simple model would be more easily understood and internalized by our clients. As a result, we use a much simpler model than most system dynamics studies made for clients.

Over the years we have spent much time experimenting with different model formulations, in search of powerful simplifications. We have, for example, increased the level of aggregation, introduced broader concepts, removed detailed structure, tested alternative loops, altered the parameterization, and experimented with noise and oscillations in the exogenous drivers. The outcome is much knowledge about what does and what does not work when the object is to understand the reference mode and recreate the history of shipping freight rates. Some is collected in Randers (2006a) on www.futuremappers.com.

## Forecasting turning points in the shipping market

### *It is crucial to have a motivating force*

Two possible drivers: science or a client   Initially, we spent our time testing the dynamic hypothesis and making sure that we had a reasonably good understanding of the workings of the oil tanker market. This unavoidably took time, not least because data was scarce, lagged and inconsistent, particularly for the capacity utilization variable. But the research councils were willing to pay for our exploratory work. After some years (around 1980) the science had been done, albeit in rudimentary fashion and not well documented. In order to proceed, we needed financial support from someone who wanted to apply our new knowledge.

A motivating client   Fortuitously, this someone appeared in 1980 in the form of a ship owner, SSB,[4] who saw the potential in our work. Without him, our effort would probably have ended with the research report of Franck and Prydz (1980b) and Randers (1984).

SSB wanted to use our insights for forecasting, and was willing to pay. Initially Randers provided some qualitative advice on future freight rates and ship values, based on his *mental* model of the shipping market. But SSB

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wanted us to upgrade the existing model and apply it to a concrete tanker trade, namely the market for supertankers ("VLCC"s). This market was dominated at the time by serious over-capacity and extremely low second-hand ship values, which appeared to offer a great investment opportunity, but only if and when the market recovered. SSB wanted "technical" support for his view that the VLCC market would soon turn up from the depressed state that had already lasted for 6 years—since 1975.

After initial hesitation, because of the traditional scepticism against forecasting in the system dynamics community (Lyneis, 2000), we agreed to help. We certainly did not agree to make point prediction of future events, but we did hope that the deterministic backbone of an interacting 4-year cycle and a 20-year wave would prove sufficiently strong to enable us to forecast the future development pattern of important shipping variables. As a result of our agreement, from 1981 onwards we have had around us a small group of ship owners and investors who have nudged us along, and paid the bills of a continuing low-level effort to make better forecasts. Over the years, this enabled us to try different forecasting methods and provided the time to test our forecasts against a slowly emerging reality. We also got the opportunity to test different ways of communicating our insights.

The publications listed in the Appendix illustrate the evolution of the project over the ensuing decades. Some high-level conclusions of relevance to the system dynamics community are presented below.

### *It is possible to forecast future turning points in the oil tanker market using a very simple model*

Dominant deterministic backbone The first part of this paper argues that there is a deterministic backbone in the oil tanker market, in addition to noise. This deterministic backbone is robust, and hence its future development can be forecast. The real future can be seen as the sum of the deterministic backbone and noise—not a "sum" in the mathematical sense, since the system is nonlinear, but as a "sum" in the practical sense that the client can understand the future as a combination of our two regular cycles plus noise.[5] Crucially, we think the noise is so weak that forecasting is feasible, at least for a time window of 1–4 years. For shorter time horizons we believe there is no structure (no deterministic backbone, no structural momentum), only noise. And for much longer time horizons, the accuracy of the forecast is lower the farther out we go, because unpredictable events eventually impact on the timing of the regular cycle. But we do expect the cyclicality to continue: it will not give way to stability or some other dynamic. This statement in itself is a forecast with a very long time horizon.

We cannot make *point predictions* with high likelihood of success. But we can forecast future *time patterns* with a useful degree of accuracy. More concretely, it appears possible to forecast the timing of the next (one or two)

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turning points in the 4-year cycle of the oil tanker freight rate, with an accuracy of ±6 months or so. Such forecasts can be made several years before the turning point, and are helpful for senior decision makers in shipping.

While we can in many cases forecast the timing of the next turning points, our simple model is incapable of forecasting the amplitude of the next upturn or downturn. Getting the amplitude right apparently requires bigger models with more structure. Luckily the amplitude is less important to our users than the timing of the next peak or bottom.

FOCUS ON MARKET SENTIMENT We found that the variable of most interest to senior decision makers is "market sentiment", not a particular freight rate. Market sentiment can be described as the average mood of the shipping community, its degree of optimism and willingness to invest. This mood is strongly influenced by recent earnings and general expectations for the next year or so. Senior shipping executives are intuitively aware of the correlation of different freight rates, and are satisfied if they know when market sentiment will turn. This is all they need to know to help decide on purchase or sale, ordering or scrapping, operation or lay-up.

It is meaningful to speak about the "average" situation in the oil tanker market. Conditions spread quickly from trade to trade, because of the substitutability of vessels (FMSM Base Case Scenario, any year, p. 28; Stopford, 2000, p. 99). If vessels are scarce in one segment, they will be scarce in others soon, since many ships can be used in different trades. If ship owners face lay-ups in one segment, they will soon spread their woes to other segments by trying to place their surplus vessels there. Thus the "average" is relatively well defined. Furthermore, communications in global shipping are so frequent and intense that there exists at any time a commonly agreed perception of the state of the market.

We chose to use a time charter (TC) freight rate as the main indicator of market sentiment. A TC rate is what the ship owner receives when he or she leases a vessel to a user for an extended period of time. The ship owner's profit (net income) equals the freight rate less expenditures for crew, maintenance and finance. The time charter profit often differs in the short term from the profit of operators in the spot market who receive the full revenue for a given trip, but have to carry all costs themselves, including bunkers, canal costs and port charges. But importantly, on a 1- to 4-year horizon the time patterns of the two are similar.

*We have found a forecasting format which does influence senior decision makers*

DOING THE IMPOSSIBLE: FORECASTING IN PRACTICE After having agreed to try forecasting for SSB, we quickly decided that the best way ahead would be to use the system dynamics model to forecast the future *pattern* of development, and then splice this trend onto historical data. The splicing is done by scaling future model values to the 6-month average of the most recent historical data.

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The resulting graph gives the reader, in one glance, both a quantitative reminder of the recent past and a picture of the likely future. Figure 9 shows a typical forecast, taken from our most recent commercial forecast (FMSM Base Case Scenario, 2006).

This splicing technique makes it possible to use far simpler models than would otherwise have been necessary. Without this technique we would need a more complicated model that could reproduce recent history within a few percent (to avoid disturbing jumps in the connection between history and forecast). A drawback is that such splicing may introduce quantitative inconsistencies in the forecast, for example if ordering and fleet size are scaled by different factors. But the time pattern remains uncorrupted.

It took us much longer to find a good way to *drive* the simple model. We needed an exogenous driver for two reasons: first, to trigger its inherent dynamics, since market dynamics are strongly damped; and second, to gain credibility we needed to accommodate—at least partly—the conventional view, namely that the shipping market is driven by exogenous events. After some years we learned that we could never win the battle over worldviews: our self-infliction view was much too alien and uncomfortable for shipping practitioners to be a helpful starting point in discussion about policy.

Thus we chose to drive the simple model with an estimate of future transport demand, calculated in a spreadsheet. It extends observed trends in historical transport demand (in ton-miles per year) some 5 years ahead. It then adds a cycle extracted by visual inspection from past data in historical consumption (in tons per year). The extension of past trends and cycles in demand is done for crude oil and oil products separately, before the two are added together, as described in Randers (2006b).

The resulting demand forecasts (called "inputs" and shown in Figure 8) are presented to the clients before they are shown the resulting rate forecasts (called "outputs" and shown in Figure 9) from the simple system dynamics model. This procedure calms the users: they find it reassuring to use estimated future demand to drive the model (in spite of repeated assurances from us stressing that small differences in future demand have little effect on freight rates over the next couple of years). Second, the procedure does marginally improve the forecasts coming out of the simple model beyond what they would have been if the model had been subject to constant demand, or more likely, demand growing at a fixed annual rate. Third, the cyclicality in the driver helps maintain the reference mode.

THE COMMUNICATION CHALLENGE We began our efforts at a time (in the 1980s) when we could not run the model live in the (very short) meetings allowed with the senior decision makers. We presented the forecasts as plots on paper, and immediately got requests for alternative scenarios: What if demand drops by 10%? What if bunker costs increase next year? We tried verbal answers, based on our understanding of the basic mechanisms, but this did not carry much weight

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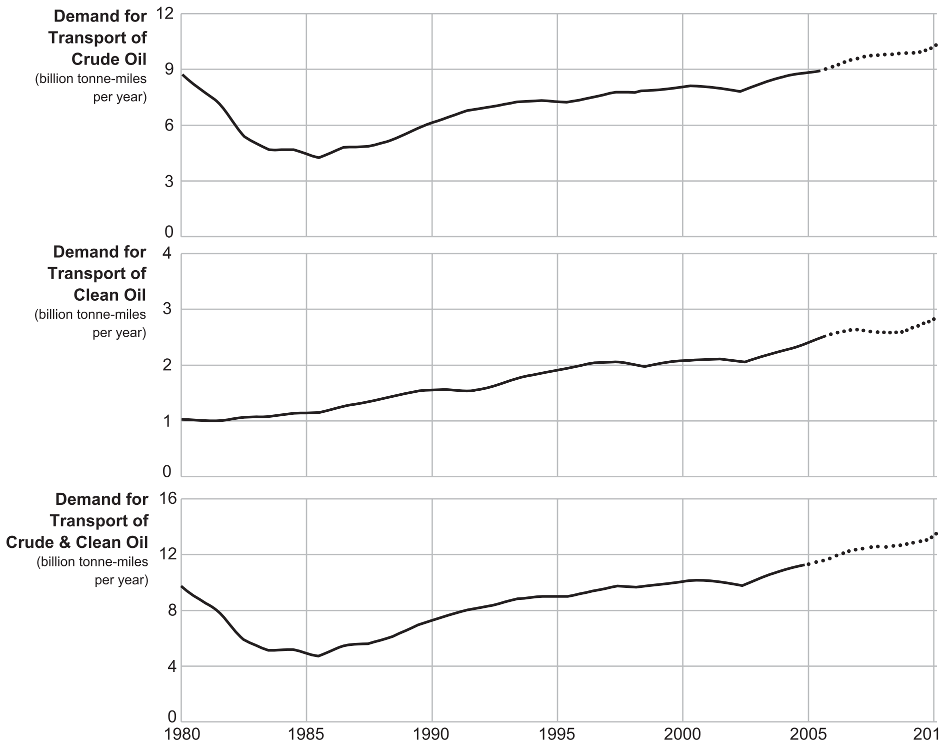
Fig. 8. An example of the model inputs used to generate the forecasts that we sell to our users: History, solid line; forecast, dashed line. Source: FMSM Base Case Scenario (2006)




since the clients did not share our worldview. We had to make alternative runs for the users, for the next meeting, which helped, but took a lot of our time.

In the mid 1980s we therefore embarked on a one-off effort to solve the communication challenge in a cost-effective way. We tried to make the model accessible to senior decision makers, so they could make their own forecasts and sensitivity runs. A special-purpose company "Future Mappers AS" was established to develop and sell this interactive product (Future Mappers AS, 1985). Significant capital was invested in the venture, and after a year a few pieces of software had been sold (at around U.S. $7.500 per piece!) to international shipping companies. But we learned quickly that senior decision makers did not want to spend time on their own with a piece of software. They delegated the job to junior IT staff. But these junior employees were not interested in rough forecasts of high-level variables like "market sentiment" on a 1–4 year horizon. They wanted detailed analyses of short-term issues, ideally point predictions for the next quarter for individual trades. Such analyses were readily supplied by our competitors (the Nortank project in Norway, and Marsoft, Inc. internationally). Since we did not believe in the feasibility of making reliable short-term forecasts (because of the lack of a deterministic

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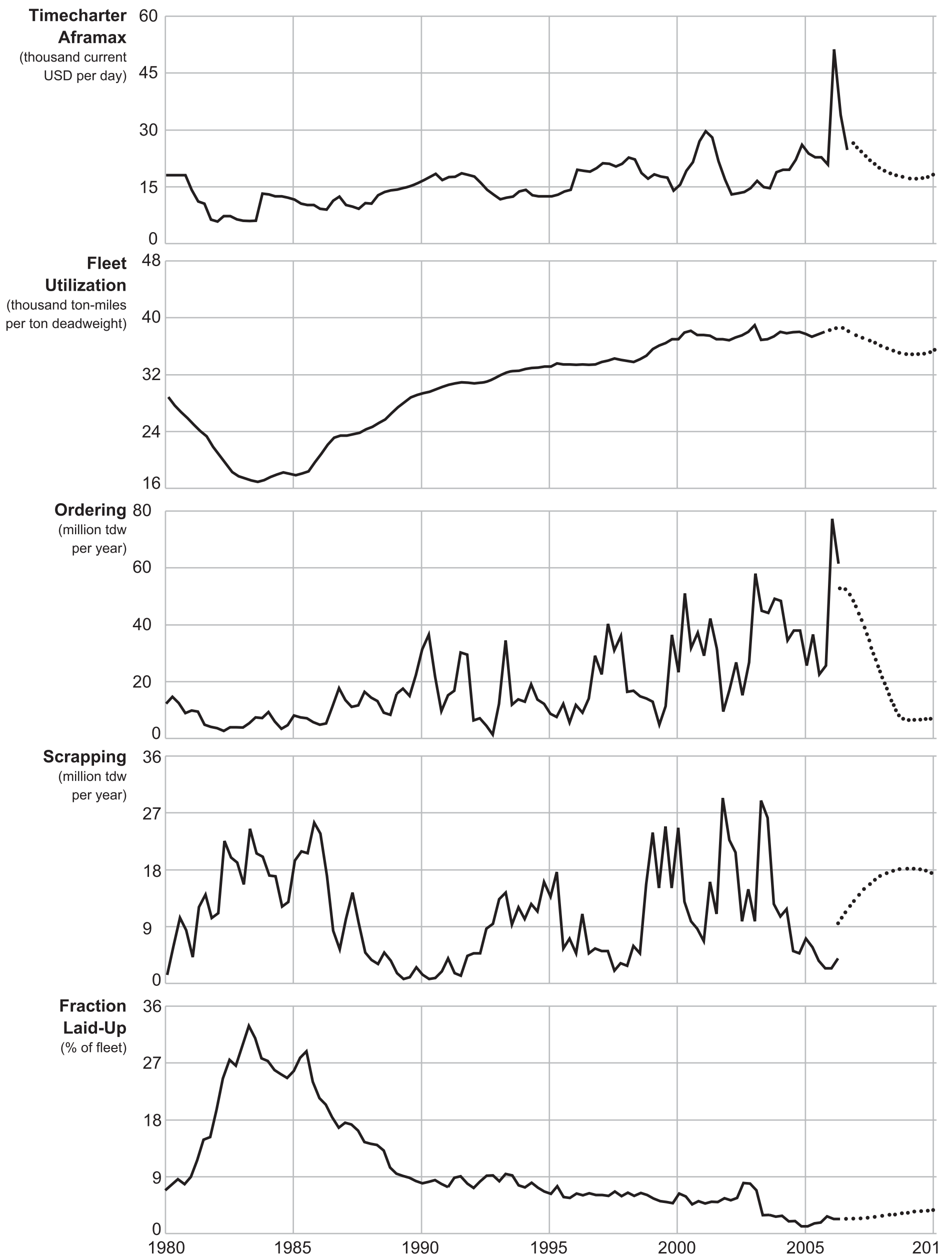
Fig. 9. An example of the forecasts that we sell to our users: model output. History, solid line; forecast, dashed line. Source: FMSM Base Case Scenario (2006) using www.futuremappers.com/Figure9-Model2006.stm.zip

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backbone in this time window) we gave up, and closed down the Future Mappers company after a year or two.

Following this failure, we concluded that we had to run the model for the users, and guide them trough the forecasts in longer face-to-face meetings. But even this time-consuming method could not easily counterbalance the barrage of opposing views which senior decision makers continuously receive from all other sources. The antidote is to provide repeated conversational meetings, covering again and again the basic mechanisms, the reference mode, the current situation in the business, the current position in the cycles and the likely future. But even when done in the warm and cosy atmosphere of a closed meeting among old friends, it proves difficult for senior decision makers to act in a contrarian way.

*Few policy recommendations follow from our analysis, and they are hard to follow*

Shipping practitioners cannot easily act upon our self-infliction view. The turbulence of the shipping market is the consequence of the *collective* action of the members of the shipping community, and cannot be eliminated by one individual, however wise he or she may be.

But one player can exploit the cyclicality (i.e., the stability of the reference mode) for his or her own profit by pursuing policy advice like:

- Sell near the peak in freight rates: they never last long.
- Do not buy if there are still ships in lay-up: then the next sustained rate increase is still years into the future. (In other words, do not get into the market before it has started to rise).
- Do not enter shipping during extremely good times: then the next decline is less than 2 years away.
- Do not lend to ship owners when they are liquid. They have ample cash only when the current upturn is just about to go sour.

Such advice amounts to a recommendation of acting in a contrarian manner. Anyone who has tried to do so knows that this is very hard in real business life. It takes strong conviction and much equity to move against the actions of one's colleagues, the advice of the shipping analysts, the editorials of the trade magazines, the small talk during trade association dinners, and the signal sent by cash flows over the last several quarters. All of these encourage each individual ship owner to act in ways which ultimately aggregate into the 4-year cycle and the 20-year wave. If a senior decision maker wants a higher return than the industry average, he or she needs to resist the temptation of the conventional wisdom. But it is difficult to maintain belief in underlying structural causes when proximate short-term events, like demand shifts, are so much more vivid. Furthermore, 2 years is seen as an eternity in the shipping business, and effects 2 years in the future are rarely considered in operational

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decision making. Business strategy is typically discussed only once a year, and at a high corporate level, without the use of technical models. Meanwhile short-termism tends to reign.

But some splendid contrarian strategists exist, and our simple model may provide good moral support in such ventures.

*The models have made good forecasts, but they have proved difficult to use*

Our clients have urged us along and kept paying for decades, so they must have derived some benefit from our forecasting effort—and we do have examples of forecasting success. In summary, we believe that our forecasting technique, using simple models driven with estimates of future transport demand, is capable of forecasting the turning points in the shipping market 1–4 years ahead of the turning point, with an uncertainty of plus/minus 6 months.

The most interesting forecast was probably made in the late 1970s, long before we had started working for external clients. At the time, our "business as usual" run, using the bigger model of medium complexity, showed no significant rise in the freight rates until 1990 (Figure 7). This meant a full 15 years of low rates, since the depression had started several years earlier, in 1975, after the huge wave of tanker overbuilding that coincided with first OPEC oil price shock in 1973. Not only did this forecast contradict the current view of the shipping community: even we ourselves doubted that the downturn would last so long. Thus we worked during the next several years to "improve" the model to get rid of its pessimistic forecasts. But to no avail. The model structure included basic mechanisms that were strong enough to overwhelm all our realistic efforts to remove the long depression. In retrospect it is clear that the model was right and we were wrong: the downturn lasted well into the 1990s, albeit with a temporary lift around 1990.

The next sign of forecasting success came 10 years later, at the end of the 1980s. After a seemingly endless decade of depression and low rates, the shipping market started to pick up. Still working with SSB, we felt in 1988 that we were about to see the first 4-year cycle of the next era of under-capacity. When the market tightened further in 1989, SSB decided to follow our advice and sell all his shipping assets, netting some U.S. $5 million. His exit really seemed like a stroke of genius when the shipping market collapsed again in the spring of 1990. We shared in the glory, as we had forecast a sudden fall in ship values in 1990 (see Figure 10), contrary to the general industry view.

This success led to a renewed intensity in our forecasting effort. A user group of some 5–10 shipping executives was formed, to share the cost of upgrading the model, providing forecasts, and presenting them verbally in the Future Mappers for the Shipping Markets User Group meetings. Initially the FMSM Group met for 2 hours every 4 months. Later the frequency was lowered, and from 2000 the group has met once a year. The composition varied some, but a core of staunch supporters has stayed the course for more than

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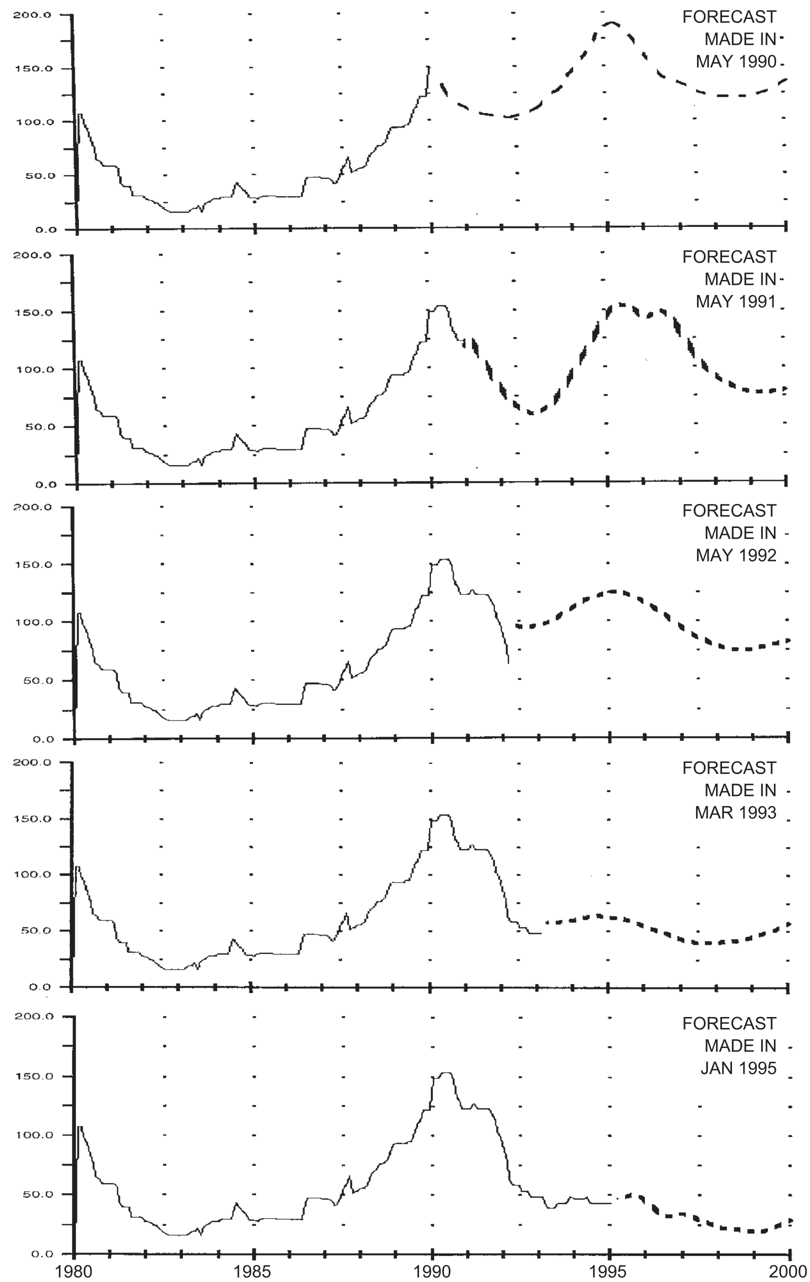


Fig. 10. An example of how the simple model correctly forecast the downturn in second-hand ship values in the early 1990s (expressed as U.S. dollars per ton deadweight). History, solid line; forecast, dashed line. Source: FMSM Base Case Scenario (various issues)

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15 years. Most of the minutes from the user group meetings are available on www.futuremappers.com (Future Mappers AS, 1995–2006).

Throughout the 1990s numerous tops and bottoms were forecast, both in tank and dry cargo, with increasing success. Our forecast of the upturn in 2003 in the tanker market and the peak in 2006, many years ahead of the event, can serve as an example (see Figure 11). The forecast was repeated year after year, providing enough time for those who decided to use the opportunity to position themselves. At least one of the members of the user group is on record as saying that the user group meetings significantly helped boost his shipping fortune, before he exited at the right time.

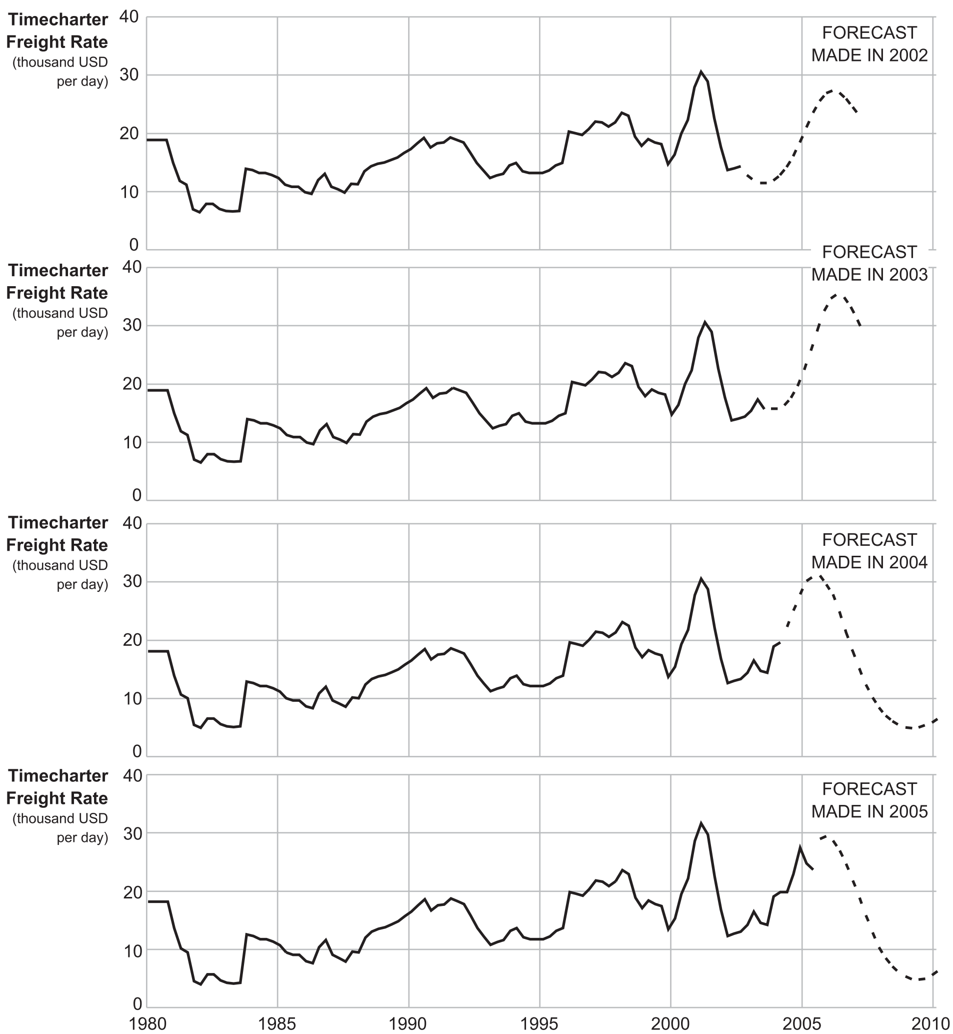


Fig. 11. An example of how the simple model forecast the bottom in the time-charter freight rate for Aframax tankers in 2003 and the peak in 2006, several years in advance. History, solid line; forecast, dashed line. Source: FMSM Base Case Scenarios, 2002–2005

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Scattered among these successful forecasts were some that failed: we forecast a mild upturn in the tanker market in the mid 1980s that hardly materialized (Bødtker, 1985), and we missed a strong downturn in dry cargo in the late 1990s (Randers, 2006a). Naturally this reduced the trust of the users—who believed more in our forecasts than in our basic mechanisms.

While an intense desire to develop a simple, good model drove the work from 1977 to 1985, the sporadic mistakes in forecasting was the prime impetus for model modification after 1990.

### *One should distinguish between three levels of implementation: change in client perspective, change in client policy, and change in client decision making*

Like any other decision in business life, the decision to buy or sell a ship, or to deploy it one way or the other, is based on numerous inputs and considerations. Hence it is difficult to "prove" implementation success in forecasting. We can document that we made the right forecast in many cases, but cannot take the credit for money made or the blame for decisions not made.

An interesting example is the FMSM User Group decision in August 2003 that it was too late to enter the upturn that had started half a year earlier. When the group met, shipping shares had already increased by 300%. The group decided it was too late and that there was little to do but to wait for the peak (which was (correctly) forecast to occur in 2006), and then sell shipping shares short.[6] This decision was the cause of much regret during the following years, since when the shares finally peaked after a 5000% (!) increase in late 2005. Furthermore, the ensuing decline got disturbed by factors irrelevant to the shipping market (like the general upturn in the world's stock markets), which made short sales impossible. Luckily our friend and system dynamics colleague John Sterman trebled his money from 2003, based on our advice.

So what can we say about our implementation success? Like Peter Senge, as cited in Cavalari and Sterman (1997), we find it useful to distinguish three levels of implementation:

(a) changing the clients' perspective/paradigm/worldview (e.g., his or her seeing the shipping environment as the sum total of ship owner decisions, rather than dominated by external events);
(b) changing the clients' policies (e.g., by selling at the top, stopping lending when rates are high, accepting that peaks are short and bottoms long); and
(c) changing the clients' actions (e.g., by deciding differently after having listened to our forecasts).

On point (a), we have not been successful in changing the world view of our clients. Our self-infliction view never sold well. This is understandable, since it amounts to a dramatic paradigm change, which rarely occurs in adults

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unless there is heavy psychological pressure. But even the less threatening change, into believing in the stability of our basic mechanisms, did not really sink in. The senior decision makers easily grasp and internalize the capacity adjustment ("investment") loop, although they keep believing it responds much quicker than it actually does. But they never internalized the capacity utilization loop. The senior decision makers accept that vessel speeds increase when freight rates increase, they accept that port loading falls, that port stays shorten, that maintenance is postponed, and that lay-ups are broken when rates rise above the refusal rate. But they underestimate the big impact of all these effects working together, particularly when one adds in the fleet optimization phenomenon: the improved pattern of fleet logistics which occurs when rates are high for a long time. The collective impact of these many adjustments is hard to measure (Franck and Prydz, 1980b, did a heroic attempt) and even harder to believe in. As a consequence, our users often worry about the impending threat to high rates of a full order book, while they would rarely (never?) think about, and fear, the approaching surge in vessel productivity and its depressing effect on freight rates.

On point (b), we have already discussed how hard it is to convince decision makers to follow the contrarian policy advice from our model. Stiff opposition from daily observation, conventional wisdom in the trade, and academic paradigms based on general equilibrium models, make it difficult for him or her to listen to our advice and stay the course.

And finally, on point (c), we have described the extent to which our users have been willing to use our forecasts as part of their decision making. Our conclusion is that our forecasts have had influence, but largely because the users over the years grew to trust us and our model, not because they internalized the basic mechanisms.

Best practice in system dynamics recommends that the model should be developed in collaboration with the user (*System Dynamics Review*, 1997). This will simplify change in the user's perspective, and make it simpler for him or her to accept policy change recommended by the model and to decide on how much to trust model forecasts. Our study supports this conclusion. But there is a serious problem when you choose to cooperate with senior decision makers, who do not have the time, or the inclination, to spend several days a year working with a model. And even if he or she chooses to participate, it may not be a wise use of their time. There is also the problem that people do not necessarily remain long enough in their job to accumulate and then use the system dynamics insights.

### *It is essential to harmonize client purpose with what the model can actually do*

There needs to be an internal harmony between the basic mechanisms, the reference mode on one hand and the perspective and time horizon of the client on the other.

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In our case, this harmony was achieved through our focus on senior decision makers, and not their aides, analysts or staff. Our customers are the ultimate decision makers, who decide on whether to build a new ship, to run it in the spot or time charter market, and to sell or scrap old vessels. These are the people who decide on strategy and makes fortunes (Onassis, Pau, Fredriksen) or lose everything (Jahre, Reksten). Many of the insights reported in this paper are less helpful to junior staff. They have other interests than the owner, ask other questions, and are more focused on the short term and on measurable detail. We chose to work with senior decision makers because our simple system dynamics model can help them. We can provide little additional value to junior staff, who already have ample tools and offers for short-term prediction.

The lessons are to avoid selling long-term analysis to short-term day traders, to understand how difficult it is to sell theoretical systems insights to senior decision makers, and to be sensitive to the huge paradigm gap between academics seeking truth and practitioners seeking profit.

## Discussion and future research

### *System dynamics best practice*

The experience from our effort to model turning points in the shipping market raises a number of questions concerning system dynamics best practice. We end by asking them, in the hope that future experience and research will help clarify the answers.

### *Is it essential to have a dynamic hypothesis to guide modelling work?*

We think the answer is yes. We accept that someone might want to make a complex model built around some collection of causal mechanisms in order to gain credibility. But we believe that making system dynamics studies without a clear dynamic hypothesis is less likely to lead to useful results. Furthermore, a dynamic hypothesis is essential if one wants to simplify a model.

Surprisingly, the review reported in Scholl (1995) indicates limited use of dynamic hypotheses in the system dynamics profession. We are looking forward to a future clarification of this issue.

### *Can system dynamics models be used for forecasting and, if yes, should they?*

We think the answer is yes on both scores, but only in those situations where there is a significant deterministic backbone in the system. This backbone can be forecast, and the forecast will be of use if there is not too much noise. This is our compromise between the traditional scepticism in system dynamics against

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forecasting and vulgar belief in point prediction. Lyneis (2000) reviews the debate and supports our view.

*Is implementation success greater if one spends more time with the client?*

Would our relative lack of implementation have improved if we had spent much more time with our client? Would it help to do 3 years of 100% effort instead of 30 years at 10%? We are not sure that more time in itself would improve the situation. But if it were possible to have the client complete more iterations between the model and the real world, comparing forecasts with actual developments, this could hopefully impact on the clients' worldview and, consequently, his or her behaviour. However, this is difficult in the time-constrained world of senior decision making, and in contexts where the time delay between forecast and observation is several years, making it impossibly time-consuming to improve the observed "forecasting quality" (see Weil, 1980).

*Is implementation success greater if one uses a more detailed model?*

Would we have had more impact on our senior decision makers if we had made a more detailed model? Adding structure to explain more of the difference between the deterministic backbone and history? We do not think so, because the discussions in our user group rarely moved to that level of detail. And as there are no short-term dynamics to forecast with a more detailed model, we could not have gained quicker confidence through short-term forecasting success.

This conclusion is in opposition to, or at least an elaboration on, existing system dynamics best practice for consultants. Weil (1980) and *System Dynamics Review* (2001) tend to argue that a more detailed model is necessary to gain use confidence. We are looking forward to future discussion of this issue.

## Notes

1. There are many freight rates. Some measure the cost of transporting a unit of cargo from A to B and is expressed in U.S. dollars per ton shipped over this distance. These vary with cargo and distance, i.e., the "trade". Others measure the cost of renting a vessel for a period of time and is expressed in U.S. dollars per ship-day or U.S. dollars per ton deadweight-day. These vary with the type of vessel. The time developments of the numerous freight rates for bulk transport of wet (crude oil and oil products) and dry cargo are strongly correlated when viewed in a multi-year perspective. Within a year they often deviate. A 'ton deadweight' is the actual capacity of a ship to carry a load.

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2. The renowned Clarkson ship brokers provide a very useful description of the global shipping markets in http://www.marisec.org/shippingfacts/Clarkson%20Report_Final%20Draft.pdf (accessed 25 February 2007).
3. We use the following terminology:

   Capacity utilization (in %) = Fleet utilization (in ton-miles per ton deadweight-year) / Maximum fleet utilization (in t-m/tdw-yr)

   Fleet utilization (in t-m/tdw-yr) = (1 – Fraction of fleet laid up (in %) / 100 %) × Fleet utilization of operating fleet (in t-m/tdw-yr)

   Fraction not utilized (in %) = (1 – (Fleet utilization (in t-m/tdw-yr) / Maximum fleet utilization (in t-m/tdw-yr))) × 100
4. Sven Sejersted Bodtker, then a 37-year-old macro-economist who had worked for years in traditional data-intense, bottom-up, shipping analyses, but wanted to start on his own as owner/investor.
5. The technically correct, but impossible to communicate, statement is: actual market dynamics will result from the deterministic backbone as excited by unpredictable noise.
6. When speculating in the shipping market as a small investor, one is forced to use shipping shares or indices, because individual ships are too expensive (U.S. $10-100 million per ship) and much too illiquid for rapid moves.

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## Appendix: Project documentation in chronological order

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