Investment Cycles in Newbuilding Market of Ice-Strengthened Oil Tankers

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Abstract

Investment cycles and their modeling have been under interest of system dynamics from its early days. Most often these cycles are caused by the uncertain profitability expectations involved in the long-term large capital investments as well as delayed manufacturing process of these needed buildings, machines and/or equipment. This paper is concentrated to the investment decisions of newbuilding market of class I A ice-strengthened oil tankers. In the European oil transport market these tankers are required only in the Baltic Sea region, and especially in the oil terminals of Gulf of Finland. The demand for capacity of these special class tankers can be derived from the handling capacity available in the most important Russian oil export terminal, Primorsk. However, in the near future planned capacity enlargements in Primorsk will create additional dynamics for the results. According to the simulation results we argue that terminal capacity could not be used in full scale in the near future, if the use of appropriate ice-strengthened tanker capacity is favored. If this ice-strengthened policy is followed, this class of tankers will face boom in newbuilding market, which is estimated to last at least for next ten years.

Keywords: Investment decisions, maritime logistics, oil transportation, Baltic Sea

Introduction

The Baltic Sea and especially the Gulf of Finland is becoming an important transport route for the increasing Russian oil exports. New harbours and oil terminals have been built and are being planned or under construction in the eastern part of the Gulf of Finland. As the volume of oil to be exported grows, the trading of large oil tankers in areas close to Finland is likely to increase considerably.

Events related to difficult ice winter of 2002-2003 raised a number of questions concerning the quality and operational suitability of the vessels in the world tanker fleet in the demanding winter-ice conditions of the Gulf of Finland. Wintertime ice-cover is a rare phenomena for large tanker ships and never before have such large quantities of crude oil been transported through demanding winter-conditions.

Tanker accidents and the resulting oil spills form a major threat to marine environment. During past decades numerous accidents have gained large-scale public attention that has forced both national and international authorities to tighten legislation and regulations concerning sea-borne transportation of oil (Tamvakis 1995, Strandenes 1999). The latest actions taken by the European Union aim to reduce the environmental risks caused by old, possibly substandard tanker ships by prohibiting them from loading and unloading in European Union harbours. This procedure, called the "phase-out", will prevent a large part of the world tanker fleet from operating in European waters and the effects may be felt in the tanker freight market.

Tanker shipping is a capital-intensive industry with a history of sudden freight market booms and collapses. Estimating future transport demand and the following adjustment of tanker capacity on the supply side has proved to be extremely difficult, if not impossible (Coyle 1977, Veenstra & Ludema 2003). Depending on available shipyard capacity, shipbuilding is a long process, taking usually from two to three years. So, most often investment decisions are completed while freight rates and demand is booming in the market, but new capacity is eventually able to serve markets e.g. three years later when there exists great possibility that both demand and prices are weak. The fact that ice-strengthened vessels tend to be more expensive than standard ones doesn't make investment decisions any easier for shipowners willing to take their share of the growing oil shipping market in the Baltic Sea. In the long-term the relatively decreasing prices of natural resources as well as the slowly but surely declining freights in bulk shipping make planning of future events an even more challenging task (Simon 1981, McConville 1999; Stopford 1997).

This paper is arranged as follows: In the following two sections investment decision dynamics of tanker shipping industry are introduced throughout previous literature. According to analysis it is concluded that system dynamics is not frequently used in maritime economics. However, market characteristics as well as relatively large, once made, and long-term investment decisions hinder uncertainty within payback; therefore, we argue that the use of system dynamics is justified in this area. We also conclude that new environmental legislation related to the quality of used tonnage will also create additional dynamics for newbuilding market. After these two sections research environment of Baltic Sea region is presented from the point of view of oil transportation through existing harbors. The analysis highlights that traditional (having also less difficult ice conditions) terminals such as Tallinn (Estonia) and

Ventspils (Latvia) are loosing their volume for new and all the time enlarging Russian terminals, especially for the most important, Primorsk. As the estimated future oil shipments through Primorsk are increasing significantly, the environmental concerns will rise due to the more difficult ice conditions as well as the limited amount of available ice strengthened oil transportation capacity. In the system dynamics simulation section we try to analyze this new situation with the use of existing data concerning oil terminal capacity, number of vessels, probability of severe winter and delay in newbuilding. Our analysis suggests that the available ice strengthened oil transportation capacity is well below the terminal capacity of Primorsk, and this will lead to very interesting outcomes in newbuilding market as well as in the utilization of oil terminal during wintertime. Simulation results also suggest that the probability for severe winter in near future has some effects to the time frame of results and their magnitude, but it could be generally concluded that our findings will exist even in the situation of less difficult icy winters. Findings of the paper give further motivation for a new research in this area, and this as well as general conclusions are provided in the final section.

Cyclical tanker shipping industry

In general the mechanism behind the market cycles is very simple. According to Stopford (1997, 44) a shipping market cycle is a coordinator between supply and demand. The supply and demand model of economics is often used as a tool for analysing market cycles. Most of maritime economists accept that the tanker market is driven by a competitive process in which demand and supply determine the freight rate. On the demand side the most important factor behind the cycles is the business cycle of the world economy. Booming world economy increases demand for transportation and when the economy goes into recession, energy consumption usually drops and eventually reduces the oil trade. Another class of factors influencing the demand are sudden economic shocks like the oil crisis or wars. These events are unpredictable by nature but still very important.

The main cause of cyclicality in the supply side is the length of the investment i.e. newbuilding cycle. Depending on the state of the shipbuilding market the time lag between ordering a vessel and taking delivery of it may be from one up to three or even four years. In extreme shipyard market conditions of the 1970's delivery times of four to five years were not uncommon. Zannetos (1966) as well as Serghiou et al. (1982) argue that shipowners commonly overestimate the economical opportunities when freight rates are rising and order too many ships with a lag of about six months from the freight peak. This generates cyclical price behaviour in both the tanker transportation and the shipbuilding market, without any necessity for cyclical demand.

Researchers in maritime economics have observed and somewhat neglected this apparent conflict. Through the last century production of oil, and the subsequent volume of seaborne oil trade has displayed a rather steady and continuous growth. Despite of this some important economic indicators of the oil shipping industry, such as the ordering of ships and the prices for transportation, have posted cyclical behaviour. This paradox seems according to Veenstra and Ludema (2003, 2) to have been translated into a maritime economics dogma stating that shipping is by its very nature a cyclical industry.

The use of system dynamic models has not been common practice in the field of maritime logistics, and especially in problems related to oil shipping. The reasons in avoiding this approach may only be guessed, but as Veenstra and Ludema (2003) argue, there are other commonly established research approaches, mostly based on econometric methods. The interrelations between the highly volatile tanker freight markets, the demand for oil transport, and the dynamics as well as delays in the tanker newbuilding market show such a high degree of complexity, that system dynamics should be well applicable in here too.

In the beginning of the 1970's R.G. Coyle among other researchers conducted a study using system dynamics in order to analyse the design of an integrated oil supply system (Coyle 1977, 306-331). The study was performed for a major oil company, which already had effective processes for managing the shipping operations, but it wanted to evaluate alternative ways of controlling their inbound oil transports. The study was based on the situation prevailing in the oil industry at that time, i.e. most of the oil company's required tanker capacity was controlled either by direct ownership or long time-charter contracts and spot-charters were used only to fill the gaps in seasonal demand. An interesting feature of this research work is the way in which tanker prices were treated in the resulting model. After an attempt to build an endogenous charter rate module, it was decided that it would become too complicated.

Eventually exogenous GNP forecasts and charter rate time series were used and the attempts to model the tanker freight market were rejected.

Oil tanker shipping shares many features with other capital intensive industries, and depreciation of this investment represents significant item in total costs of shipping operator (Bendall & Stent 1987). One particularly important and also difficult feature is the long time delay in capacity build-up. Ford's (1997) study on the construction delays in the electric power industry provides a good analogy with the tanker shipping industry. Both of these industries have experienced a surge in orders for new capacity and in construction lead times as demand grew rapidly in the early 1970's. Changes in general economic conditions resulted that both industries ended up with excess capacity lasting through most of the 1980's (Sterman 2000, 424-425, see also Stopford 1997, 130; Berends & Romme, 2001).

Veenstra and Ludema (2003) employ a system dynamics approach in their analysis on the market cycles of tanker shipping. Based on observations by Zannetos (1966) they also assume, that there exists no outside influence in the tanker market that could create cyclicality in the freight market or in the orderbook of new vessels. Simulations with a model confirm that the cycles are created by the delayed delivery of new vessels and to a certain extent by the over-optimism of shipowners, who are eager to invest in new vessels and over estimate the commercial opportunities when freights start rising. In a broader context of managing innovations in shipping and applying various design methodologies in that process Wijnolst (1995, 342-345) also see system dynamics as an efficient way to understand the dynamic behaviour of complex systems like many shipping operations.

Some Special Characteristics of Newbuilding Market

Economical life of vessels has significant influence on the newbuilding market. In addition to the technical obsoleteness of a vessel reaching the end of its life cycle, political decisions may force ships to be taken away from operation prematurely (Strandenes 2002, 200). To certain extent this may be the case when new stricter rules are being imposed on single-hulled tankers. As existing capacity has to be replaced earlier than technically necessary, orderbooks of competitive shipbuilders are filled and time-delays in newbuilding increase even more than would be the case in normal market conditions.

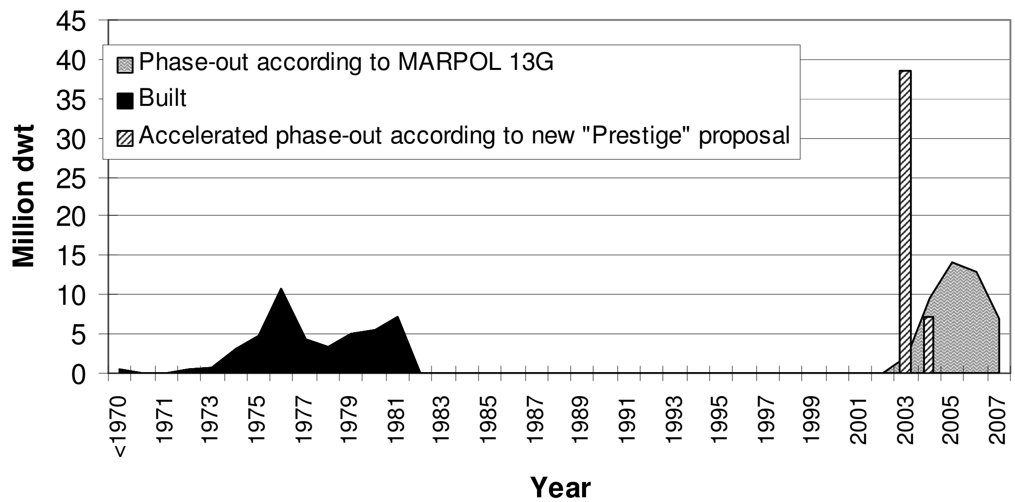

Figure 1 Phase-out pattern for single hull category 1 “pre-MARPOL” tankers. Source: Statistical Data on Available Tanker Capacity 2003

Political decisions related to tighter environmental legislation is at the moment creating additional dynamics for the need of building new vessels. The main reason is in the age of used vessels; among different oil tanker types capacity was mostly brought to markets during newbuilding boom of late 70’s and early 80’s. Figure 1 highlights this dynamics more, where the situation of “pre-MARPOL” (single hull category 1) tankers is presented. Expected results of two different political decisions are shown in figure: (1) after Exxon Valdez oil spill in 1989 International Maritime Organization decided with MARPOL Regulation 13G that old single-hull tankers should be removed from markets in the end of year 2015 (Wood 1995, Tamvakis 1995), and (2) Prestige oil spill in 2002 resulted to accelerated removal of these single-hull tankers, which was approved by IMO after lengthy discussions.

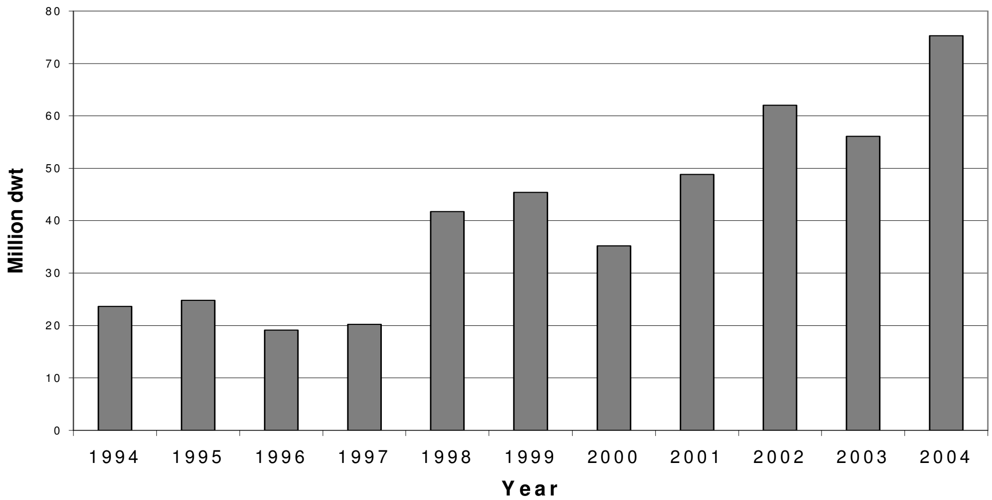

Figure 2 Oil tanker orderbook in January 2004. Source: R.S. Platou Shipbrokers' The Platou Report 2004

As could be assumed, the sudden decrease of available vessel tonnage in markets is being compensated by booming newbuilding (Figure 2). The level of orderbook in 2002, 2003 and 2004 is higher than at any stage since the tanker newbuilding boom of late 1970s. Over the past ten years the average annual growth of the tanker fleet capacity has exceeded the average growth of oil sea-borne trade and for the most of the time there has been surplus capacity in the market. During the first three months of 2003, 137 tankers totalling 15.5 million dwt were ordered compared with only 28 tankers during the first quarter of 2002. Deliveries from shipyards in 2003 include 16 Panamaxes, 28 Aframaxes or LR2 product tankers, 14 Suezmaxes and 23 VLCCs (Statistical data on available tanker capacity 2003, 9; Swedish Shipping Gazette).

Research environment: Oil transhipment in the Baltic Sea

Ports and oil terminals in the northern Baltic Sea and especially in the Gulf of Finland area are affected by winter ice during several months of the year. Large oil export terminals in Latvia and Lithuania (Ventspils, Butinge and Klaipeda) could be considered ice-free all year round. However, ice-conditions are most severe in the eastern part of Gulf of Finland, where large Russian oil export terminals and ports Primorsk, Vysotsk and Batareinaya are currently situated or being planned to be. Also the Muuga oil terminal in Tallinn is affected by ice during the winter, as are all oil harbours in Finland.

Competition between the Baltic seaports for transit freights has intensified. All Baltic States have taken measures to modernize basic port infrastructures, to provide modern superstructure (terminals), to increase sector privatisation and commercialisation as well as to improve transport logistics and storage facilities. The major Russian oil companies have successfully played off the Baltic ports against each other and pressed down transit fees. In addition, Russia has increased its own direct sea transports through *St. Petersburg* and its other Baltic Sea ports, *Kaliningrad* and *Primorsk* oil terminal.

Table 1 Oil and oil products cargo turnover 1997-2003 in million tons. Figures for 2003 are from the period January-August. Source: Port Authorities

	1997	1998	1999	2000	2001	2002	2003 1-8
Primorsk	-	-	-	-	no data	12.2	9.5
St. Petersburg	5.8	6.4	7.4	7.4	9.0	10.6	No data
Tallinn	8.1	11.1	14.5	17.8	21.0	24.3	15.9
Ventspils	27.1	26.0	24.3	26.3	28.7	20.1	8.4*
Riga	2.1	2.0	2.2	2.8	3.4	5.2	3.6
Liepaja	0.3	0.1	0.2	0.4	0.5	0.7	No data
Butinge	-	-	0.7	3.5	5.1	6.2	7.5
Klaipeda	3.6	2.2	3.9	5.2	5.1	6.7	4.4
Kaliningrad	0.9	0.9	0.9	1.0	1.9	4.7	No data
Gdansk	5.7	8.1	7.0	5.8	7.0	5.7	6.6
Total	**53.6**	**56.8**	**61.1**	**70.2**	**81.7**	**96.4**	

* = only Ventspils Nafta

Russian oil production and exports are estimated to increase substantially over the coming years, which is a source of optimism for the Baltic ports handling oil transit cargoes (statistics could be found from Table 1). Insufficient oil export capacity in Russia and bottlenecks caused by weather conditions in main export ports of *Novorossiysk* and *Primorsk* should allow the Baltic States' ports to stay in competition, if transport economics would be the only determinant. However, due to the decision that own infrastructure, primarily in *Primorsk* but as well in *Vysotsk,* is about to be enlarged in the near future, the high possibility exist that these harbours are favoured in the oil shipments (these ports together should have above 60 million tons per year of available terminal capacity in 2005).

If these near future plans of harbour capacity enlargement is about to be realized, and shipments will be directed throughout of them, the sea transportation of oil in ice conditions will increase considerably. If estimated capacity of 60 million tons per year is transformed to monthly basis, this will mean that at least 5 million tons of oil is being transported every month. On the average ice-season will last for 90 days (varies between 60 and 120 days), which means that 15 million tons of oil is about to be transported in these challenging conditions. However, the real problem lies in the fact that different ice conditions require completely different type of vessels. For example, in severe winter (21 percent probability according to statistics; see e.g. Finnish Institute of Marine Research 2003, Leppäranta 1988) the ice-conditions require tankers equipped according to Finnish-Swedish ice-class I A (ice strengthened hull and more powerful engine) to be used in the oil transport (to avoid properly the risk for an environmental accident). Due to the low probability of severe winter, the available capacity of these I A ice-class tankers is very limited (most often these are not available in freight markets, since users and shipping operators favour longer-term contracts due to higher investments). In other words, in the forthcoming years it is expected that during a severe winter lower ice-class tankers will be needed and used in the area when handling the increasing volumes of oil transportation. It is clear to note that this situation will increase considerably the probability for an environmental accident.

Model of the wintertime oil shipments from Primorsk oil export terminal

Due to the several general (related to investment decisions and delayed production) as well as case specific reasons (winter, varying ice conditions and limited vessel tonnage available) we were motivated to build a system dynamics simulation model concerning the issue of newbuilding of ice-class I A tankers. As investment decisions of these tankers are mainly driven by the need of Primorsk terminal, we were able to link these future oil shipments to the new capacity enlargement decisions. In the beginning of the simulation period the total transport capacity is based on situation, which prevailed in winter 2002-2003, when only four sufficiently reinforced Aframax (80,000-120,000 tons) tankers were available to the trade. Assuming a normal trading pattern, where cargo discharge takes place in the UK-Continent area enabling three roundtrip voyages in a month, these four vessels would have a combined cargo capacity of 1.2 million tons per month in open water. Ice-conditions slow down the speed of ships in the northern Baltic Sea and more capacity reduction is caused when tankers have to wait for ice-breaker assistance. In reality these are very complex issues and subject to many operational decisions, but for modelling purposes it is assumed that severe ice-conditions reduce the total transport capacity of existing tankers to 800,000 tons per month and thus to 2.4 million tons of oil per one winter season.

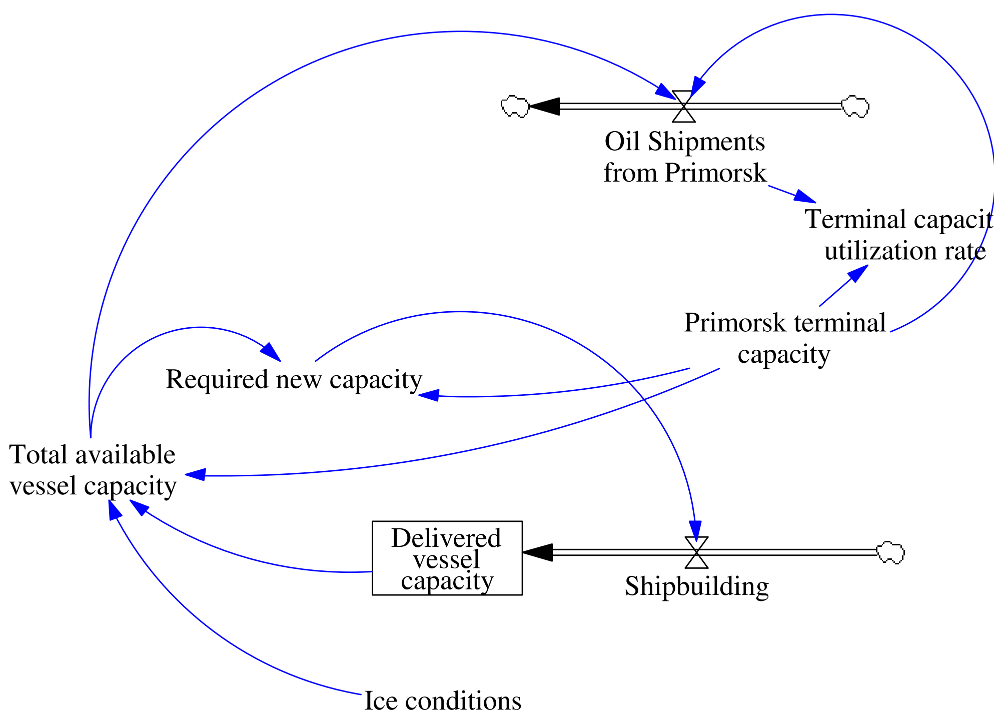

Figure 3 The system dynamics model used to simulate the wintertime oil shipments from Primorsk. Equations and parameter values are presented in the Appendix

Ice-conditions have an effect on the ‘Total availability of tanker capacity’ in the model. The randomness in appearance of winter ice is taken into account in a way, where the tanker capacity is limited when there is ice, but assumed infinite (or at least equal to the terminals capacity) when winter ice for one reason or the other doesn't exist.

Required new vessel capacity is the difference between Primorsk terminal capacity and total available vessel capacity. As mentioned, differences can occur only, when ice-conditions limit the tanker capacity. Shipbuilding is induced by insufficient supply of ice-going tankers and it includes a delay of two years before newly constructed tonnage is delivered and included in the total vessel capacity. The delay assumption of only two years may in today's shipbuilding market be overoptimistic, but it is correct enough for the model. Because the purpose of this model is mainly to analyse the characteristics of a system where the pattern of increase in tanker tonnage is the major concern, the effects of phasing-out obsolete tankers and scrapping vessels in the end of their economical life are left outside the model. Another reason for this is the fact that the current average age of large ice-strengthened tankers is less than two years.

In the model the export capacity of the Primorsk terminal is at the beginning set to one million tons per month (correspondingly this will mean three million tons per winter season). This represents the terminals true capacity when it was taken in operation in December 2001. In the model the capacity is expanded with large steps of four and a half, and three million tons per season after two and three years from beginning of operations, following the capacity increases that have taken or are announced to take place also in reality. This kind of capacity expansion in large steps is very realistic, since it represents the capacity of new pipelines leading to the port (currently under construction). Even in real world this new capacity can be taken into operation at one moment once the construction of the whole pipeline has been finished. In the model the final capacity of the terminal is 10.5 million tons per ice-season, which is assumed to last for three months.

In the model the total volumes of oil to be shipped from the terminal cannot exceed the total available capacity of tankers. Terminal capacity utilization rate represents the relation between actual shipments and existing export capacity. In real world a high level of capacity utilization is expected to reflect a good return on invested capital for the terminal owner, and vice versa.

Simulation results

As can be seen in Figure 4, the performed simulation runs with different probabilities for severe winters reveal interesting differences in how the tanker capacity increases. The time-period used in the simulation runs was 100 years or ice-seasons, but the results are reported using a time-period of 50 years on the x-axis in Figures 4, 5 and 6 in order to make the patterns of behaviour more visible.

As was obvious, the available tanker capacity exactly follows the increases of the Primorsk terminal capacity, when probability of severe winters was set to zero in the simulation. This is a result of theoretically infinite supply of tonnage, since all suitable sized tankers in the world fleet may be used in the trade. When the probability of severe winter was set to either 100 per cent, meaning that all winters are difficult, or 80 per cent, it takes in both cases approximately ten years before the capacity of ice-going tankers reaches the terminals maximum capacity. In these cases the newbuilding delay also forces the capacity to overshoot the goal-level before correcting measures are taken.

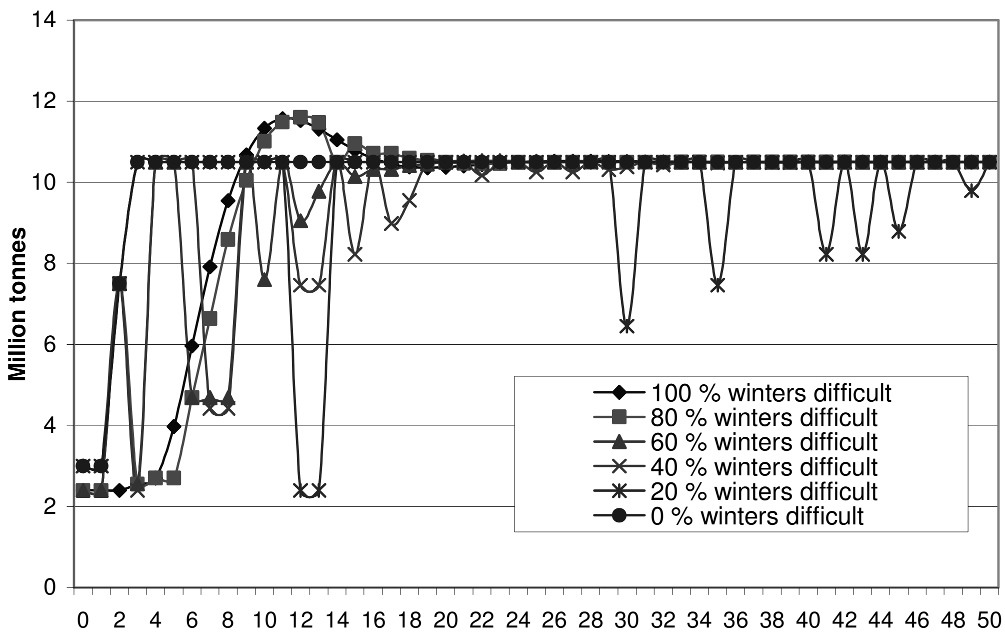

Figure 4 Tanker capacity development per winter season in different simulation scenarios using different probabilities for severe winter

With lower simulated probabilities of severe winter, 60 and 40 per cent, the tanker capacity reaches the goal level only after 15 to 20 years. Even more striking is the observation in the tanker capacity build-up, when a realistic probability for severe winters, 20 per cent, was used in the simulation. In this case it takes approximately 50 years before the vessel capacity reaches the goal, export capacity of the Primorsk terminal. This results from the connection between probabilities of severe winter and deficits in available vessel capacity, which ultimately gives the push for shipbuilding. The more mild winters, the less ice-strengthened capacity is to be constructed. In reality as well, the incentive for newbuilding construction is the high freight rate, which is caused by tonnage deficit due to insufficient supply of tankers strengthened for navigation in ice.

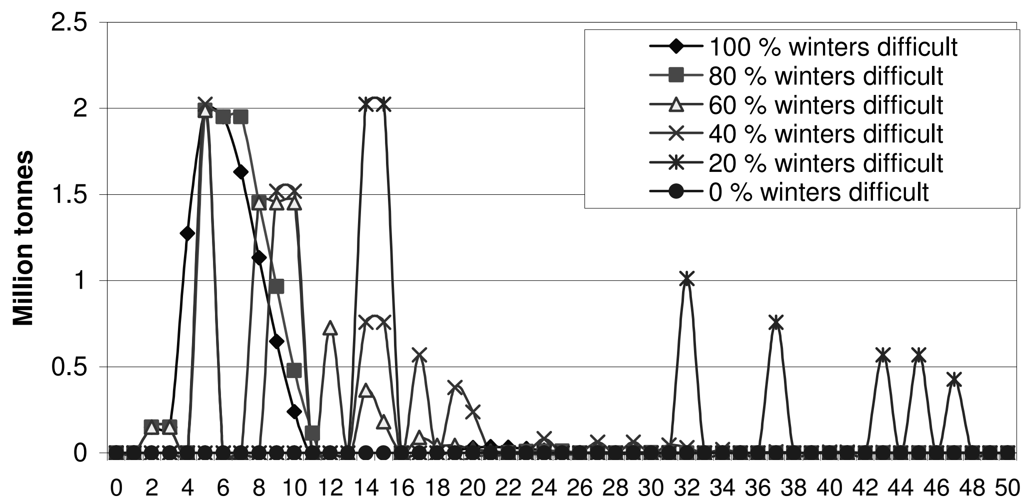

Figure 5. Tanker newbuilding patterns in different simulation scenarios

The number of tankers to be constructed can be induced from simulated carrying capacities of newbuilt tankers presented in Figure 5. With the estimated transport capacity of 600,000 tons per ship during one winter season, a simulated newbuilt carrying capacity of 2 million tons per season can be translated to approximately three new 100,000 dwt Aframax-tankers. Assuming the parameters used in the model, a total fleet of 18 ice-strengthened tankers would be needed and 14 of them would need to be constructed in order to fully cover the transport demand also in a severe winter.

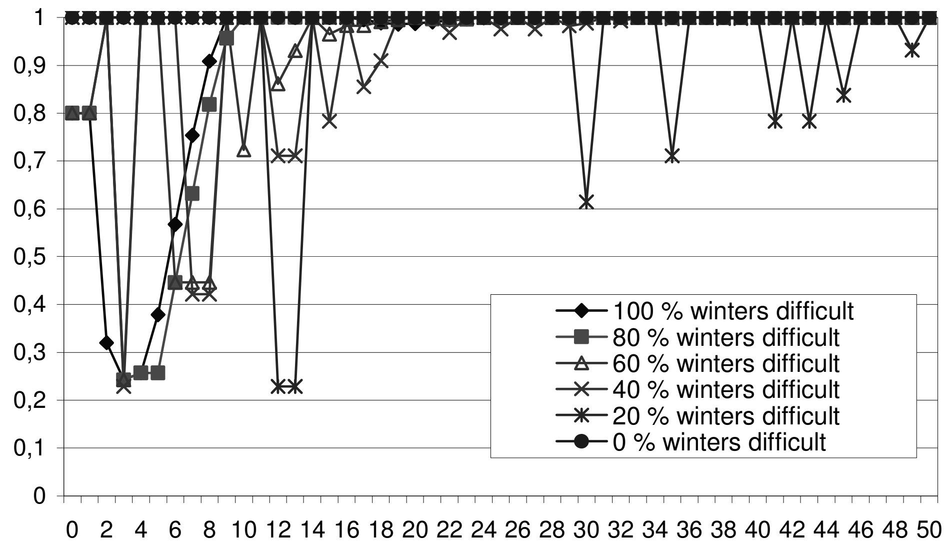

Figure 6. Primorsk terminal capacity utilization rate in different simulation scenarios

Simulation results show also, how varying ice conditions and delay in shipbuilding affect the oil shipments from the Primorsk terminal. This is represented by Figure 6, which shows the capacity utilization rate of the terminal in different simulation scenarios. Exactly as in the earlier example case with available vessel capacity, the terminal's utilization rate is not limited by vessel capacity when there are no severe winters. In all other simulation scenarios the utilization rate of the terminal capacity falls to very low level, even below 30 per cent. In those simulation scenarios where the probability for a severe winter was 100, 80, 60 or 40 per cent, the resulting construction of new tanker capacity corrected the low levels of terminal capacity utilization either approximately until year 10 or at least before year 20.

In the simulation scenario with a probability of 20 % for a severe winter, the vessel capacity does not increase fast enough or at all in the beginning, because circumstances leading to it, difficult ice winters, are all too rare. This means that if severe winters occur after a relatively long period of milder winters, periods of very low terminal capacity utilization may take place at very late points of time. The model assumes that only ice-strengthened oil tankers are used when oil is transported from the terminal in the wintertime. In reality the situation may, however, be very different.

A sensitivity analysis was also performed in the simulation model. The different values for probability of severe winter were retained as they were, but the tanker newbuilding delay was altered from two years to either one or three years. With these different parameter values the patterns of behaviour in total available vessel capacity and terminal capacity utilization rate were very much like the ones in the simulation with the original parameter value of two years newbuilding delay. The only difference was that it only takes either a little shorter or longer time before the capacity reaches the desired level, or that the terminal operates at decent ratios of capacity utilization. In all the conducted simulations the probability of severe winters was thus the most important factor behind the different patterns of behavior.

Conclusions

The completed system dynamic simulation reveals very interesting patterns in the wintertime oil transports from the Primorsk terminal. It is perhaps not very surprising that it takes time to build a sufficient fleet of new ice-strengthened tanker ships and that it takes even more time when there is no clear economic incentive for the owners to do so. Considering the nature of tanker spot charter market especially in the northern Baltic Sea, the only incentive for investing in suitable new capacity comes in the form of severe winters and high freight rates caused by current tonnage under-supply.

The results from the simulation show, that if tanker newbuilding is encouraged only by occasional severe winters and the following high freight rates as a result of tonnage deficit (as seem to be the case also in reality), the fleet of ice-going tankers is likely to grow very slowly indeed. The reflection of this is the low terminal capacity utilization rate during difficult winters, if only ice-classed tankers were to be used in the shipping of crude oil from Primorsk terminal in reality. From an economical point of view this would be a completely unsustainable situation for both the Russian oil companies, who rely on the services provided by that terminal in their export operations and to the owner and operator of the terminal, the Russian state's pipeline monopoly Transneft. It is therefore more than likely that vessels without proper icestrengthening will to some extent be operating in the Gulf of Finland in the coming winters too.

At the same time the simulation results also give an alerting signal to those who are concerned about the environmental aspects of increasing wintertime tanker shipping in the Gulf of Finland. The consequences of only one single large-scale tanker accident would be devastating for this environmentally sensitive sea-area, lasting possibly for decades.

The conducted rough simulations point out some of the risks of entrusting the profitability of such large investments with probabilities of severe winters. In addition they give a reason to believe that in order to guarantee adequate shipping capacity in the wintertime already from the beginning of the terminal operations or completions of capacity increases, tanker newbuilding orders should be placed well in advance. Perhaps investment decisions in tanker shipping capacity should be made not later than simultaneously with decisions to enlarge the export capacity. In practise this would mean long-term chartering agreements between the shippers and shipowners, because without some certainty of future employment at freight rates above the average of standard vessel’s freight level, expensive ice-strengthened tankers will remain as risky investments.

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Appendix Equations used in the simulation model:

(01) Delivered vessel capacity= INTEG (Shipbuilding,0)
Units: Million tons per winter season

(02) FINAL TIME = 100
Units: Year
The final time for the simulation.

(03) Ice conditions=RANDOM UNIFORM(1, 100, 0)
Units: units per season

(04) INITIAL TIME = 0
Units: Year
The initial time for the simulation.

(05) Oil Shipments from Primorsk=
IF THEN ELSE(Primorsk terminal capacity>Total available vessel capacity, Total available vessel capacity , Primorsk terminal capacity)
Units: Million tons per winter season

(06) Primorsk terminal capacity=
3+STEP(4.5, 2)+STEP(3,3)
Units: Million tons per winter season

(07) Required new capacity=
(Primorsk terminal capacity-Total available vessel capacity)/4
Units: Million tons per winter season

(08) SAVEPER =
TIME STEP
Units: Year [0,?]
The frequency with which output is stored.

(09) Shipbuilding=
DELAY FIXED(Required new capacity, 2, 0)
Units: Million tons per winter season

(10) Terminal capacity utilization rate=
Oil Shipments from Primorsk/Primorsk terminal capacity
Units: percent

(11) TIME STEP = 1
Units: Year [0,?]
The time step for the simulation.

(12) Total available vessel capacity=
IF THEN ELSE(Ice conditions>100, 2.4+Delivered vessel capacity, Primorsk terminal capacity)
Units: Million tons per winter season

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