Investigating Ship Building Supply and Demand Forecasting Trends – Overview

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Abstract— The huge importance of the maritime shipping industry to the global economy was confirmed by the United Nations specialised agency for maritime affairs, the International Maritime Organization, which reported that the world has changed to the point where almost no nation can be fully self-sufficient and that the global economy simply could not function without a vibrant shipping industry. Of all the world's great industries, shipping is perhaps not only the most international, but also it is the one that has considerable effect on most of the world's population. The shipping industry has a major effect on the transportation of goods, intercontinental trade of raw materials, import and export of food, fuels and manufactured goods. Production of goods increasingly takes place in more than one country and this is one of the main reasons for the growth of seaborne cargo in recent decades. Increasingly goods are often partly made in one country, processed in another and finalised or assembled in a third with components coming from all over the world. This globalisation has given the shipping industry a major responsibility since it has a significant effect on the end price of all goods it transports. Having forecasting information about how many ships of different types are required, and when, would have a substantial positive impact on efforts to reduce the ever increasing costs of sea transportation. Here, cost reduction impact would be achieved by better matching the type of ship, and its operating costs to the type and volume of goods requiring transportation. The main aim of this research illustrated in this paper was to develop an accurate and reliable method of forecasting supply for various types of ships. To achieve this aim several key questions were identified leading to a number of objectives which were transformed into a set of tasks. A number of variables were identified that needed to be predicted in terms of the features of types of vessels involved and the goods they transport. Here the main variables to be analysed had to be identified along with their effects on the supply and/or demand for given types of vessels. The volatile nature of shipping was considered and required the intended forecasting model to be able to monitor trends on a regular basis and to sense sudden changes in demand or changes which may have an impact on the reliability of the accuracy of the predicted value. The research identified the most effective forecasting technique which was the neural network model developed for this work. Additionally, the work here identified the relationships between supply and demand for shipping with a view to exploring the nature and the strengths of these relationships. It was noted that there is a very strong relationship between supply and demand hence providing a means of accurately estimating the demand values from predicted supply values for various types of ships.

Index Terms— Forecasting, shipping, demand and supply, market trends , future shipping trends, ship life cycle, forecasting capacity, forecasting methods, expert systems, neural network, correlation , regression .

1 Introduction

THE lead-time in designing and manufacturing a ship is often a few years and the product life cycle for a commercial ship is about 30 years (1). By the time a ship is built and put into operation, the demand need in the market could be very different than the time when the decision was made to build it. A ship-owner traditionally makes profits not just by operating the vessel but also by buying when demand for shipping is low and selling a vessel when demand is high. In the ship life cycle, it may have more than one owner, how-ever it is vital that each one is able to make the decision to buy at the 'bottom of the market' when ship prices are at the lowest and to be able to sell at the 'top of the market' when ship prices are at their highest. Shipping is a capital intensive business and a good knowledge of a ship's life cycle and its management is crucial in avoiding financial losses or making financial gains. Shipping is affected by many factors for example the most economic crises that are happening around the world. Financial gains and losses are normally substantial since shipping is often a huge investment that needs to be safeguarded against future trends of supply and demand. To this end, forecasting techniques are essential for aiding the investment decision making process in shipping enterprises.

Shipping economic models (11, 14, 18, and 20) consider future supply and demand for vessels of various kinds using the number of existing ships, those being recycled or intended for recycling, and new orders. (2) takes into account any new shipping developments worldwide when projecting demands for ships into the future. Recent research (2, 7, 12, 14, 20) have reviewed future requirements by examining the number of different types and ranks of seafarers that will be needed in the future and use this information to predict future demand for various aspects of shipping modify the header or footer on subsequent pages.

2 Research Objectives

This research initially identified the variables that needed to be predicted in terms of the features of types of vessels involved and the goods they transport. Here the main variables to be analysed had to be identified along with their effects on

the supply and/or demand for given types of vessels. The initial literature search included searching for sources of data which could be used to analyze trends in supply and demand in shipping, and gain an understanding of the cyclical factors and regional developments and the special constraints, such as lead-times, for provision of products and the design and build of ships. Tinbergen (1931) analysed the cyclicality of the shipbuilding market (23). (15) noted that this research identified that the condition of shipbuilding markets is dependent on the amount of freight offered for shipping and that the freight rate then is in turn dependent on shipping tonnage present in the market. These causal relationships are believed to lead to an endogenous (i.e. internal) shipping market cycle caused by the time lag between the demand for shipping capacity and the actual availability of this capacity Additionally, Tinbergen (1931) comments that there is an evidence of exogenous (i.e. external) disruptions causing the cycle to act unpredictably at different periods of time (22).

3 Supply and Demand Relationship

This relationship between supply and demand has been known for some time (2) but has never been systematically researched. Various components of supply and demand are illustrated in Figure 1 i.e. the importance of forecasting demand for shipping on various elements in the industry. If the demand for a given type of ship increases, the price of that type of ship and/or the freight rates. In his theorem, (3) theorem suggests that low total tonnage leads to high freight rates, which is the basic economic logic of supply and demand. Ships orders during a prosperous market period are delivered approximately one year or more, thus increasing the total amount of tonnage (capacity/supply). However, the argument by Koopmans (1939) is that the shipbuilding market is influenced by expectations concerning the degree of balance between world fleet/supply capacity and demand for shipping. Koopmans's main reason reliance on expectations, which is the time lag between ordering and delivery of new vessels. (7) The reasoning for this is that the maritime market situation at a particular point in time is shaped according to orders that will be placed several years in the future.

4 FORECASTING OVERVIEW

Forecasting has become a major subject of research as it provides a means of predicting future trends for a given product or service. In recent years intelligent systems have been used to develop forecasting models. The emergence of intelligent systems, a broad term, covering a range of computing techniques that have emerged from research into artificial intelligence (9) has led to both development of symbolic approaches, knowledge that is expressed in words and symbols and numerical approaches such as neural networks. Artificial intelligence is primarily composed of expert systems and neural networks. According to (9), expert systems are a type of knowledge based system designed to embody expertise in a particularly specialised domain. In ultimate form an expert system could have all the necessary knowledge to automate a process, for example, the autopilot system of an aircraft. On the other hand, there may be little or extensive amounts of information but not in the form that can be used to develop an expert system but sufficient to establish relationships between two or more sets of data. These types of arrangements to establish relationships are referred to as neural networks or artificial neural networks (ANN). In many cases, therefore, knowledge has to be developed based on the data and information available. Collection of knowledge for a given forecasting application is referred to as knowledge-based systems (KBS), where such systems and their main components are described by (9). Neural Networks are basically based on the perceived work of the human brain (18, 22, 25). The main aim of the paper here where an attempt has been made to consider conventional forecasting techniques and evaluate their applicability in achieving a stated aim of this programme of research which is to review the current forecasting techniques and to ascertain if these techniques may be adequate and/or sufficiently accurate to predict future demand for ships that transport freight.

Irrespective of which forecasting techniques or models are used, according (23), the basic tasks involved in the forecasting process are data identification, data collection, data analysis and decision making. In forecasting, once data is identified and collected, analysis becomes significant.
(23) stated that Data analysis is the processes involved in establishing the relationship between two (or more) sets of data, such as variation of demand for a given product over a period of time with particular attention paid to their effect on the quality of data. Here for forecast data to be acceptable the input data has to be fit for purpose. Several researchers have developed forecasting models including (4, 24, and 25). In recent decades forecasting has become less reliant on the subject in-puts of experts and more focused on using higher levels of mathematics and technology based data collection methods

5 FORECASTING TECHENIQUE

There are a wide range of forecasting techniques that attempt to predict price for current tonnage in the global market which make use of evaluations of supply/demand relationships of which (4,17,25) observe that secondhand ship prices are flexible whereas newbuilding prices are relatively rigid, implying that newbuilding prices adjust to secondhand prices over time. (12), considers such an argument to be open to criticism since the shipbuilding industry is supply-led and hence cost driven, whereas secondhand ships are demand–led and hence market driven. The price of a vessel has an impact on the supply side of the shipping industry since shipbuilders frequently start new builds when they are of the view that in one year's time or more, when the vessel is constructed, its prices will be such that they will be able to profit from their investment. However, considering the shipping market has proven to be so volatile and speculative, as has been the case in the past few years, many ships ordered a

year or two ago are now worth a lot less than their cost. This in turn means that there is a less demand which forces the shipbuilders to stop building new vessels or owners to cancel orders if the financial penalties are bearable. Figure 1 shows the interrelationship between the supply and demand sides of the shipping industry has been used to identify the various factors of the market for further study in parallel with those identified in (8). According to (9), secondhand and new ships can be made available in different timeframes, accordingly different trading conditions, costs and risks can be applied. The study argues that secondhand ships have shorter trading lives than the new builds as they may have technological advantages.

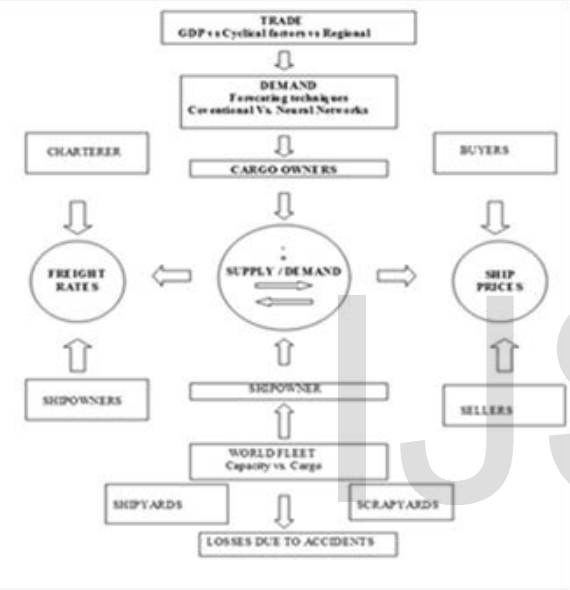

Figure 1 : Components Supply and Demand in Shipping

Although, researchers have been found to adopt supply and/or demand approaches to analyzing shipbuilding and selling (5.20), whether reviewing the cost of building a new ship or evaluating the price of an existing one, what is essential is to have a flexible forecasting model. Such a model must make use of an accurate method of predicting supply or the price of building or selling a ship. It must also be flexible enough to be applied in unpredictable and risky shipping markets where increasing demand may be constrained by shipyard capacity and high secondhand ship prices or a depressed and oversupplied market with low secondhand ship prices. When the prices of secondhand ships are high this may en-courage new ships to be built and/or the recycling of ships that are considered old. It is also acknowledged that knowing the various factors in shipping and the way the shipping market reacts and subsequent impact on ship prices would provide the investors, ship owners and builders with essential insights for timing their investments or making sell or recycle decisions.

4.1 Demand and Supply Prediction

There are several research works which have realized the difficulty in predicting supply and demand for ships in volatile market conditions. (4) developed a theoretical error correction model focusing primarily on estimating new and secondhand ship prices. The forecasting performance of the model was compared with a theoretical Autoregressive (AR) model for all ship types under investigation. In the study here, although performance comparison of the forecasting model has been compared to conventional forecasting techniques, the forecasting has been based on the application of a complex neural network model which is supplemented by an error correction model referred to as the RZ recovery system (22, 23). A version of this recovery system has been applied will be illustrated in the following research paper.

5 FORECASTING PITFALLS

The research substantiated the pitfalls in forecasting demand for ships in some cases, for example, data for 'world fleet' (capacity) is available yearly and hence forecasts can only be determined for one year ahead. However, within a period of a year in the shipping industry there could be many significant changes and fluctuations in shipping market indices which may influence demand and price of ships.

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6 CONVENTIONAL METHODS OF

FORECASTING

Forecasting has become a major subject of research as it provides a means of predicting future trends for a given product or service. In recent years intelligent systems have been used to develop forecasting models. There are many forecasting systems relying on correlation or regression techniques. The following paragraphs outline the main characteristics of these methods used in forecasting (25)

6.1 Correlation

The strength of the association and relationship between two variables can be measured using the correlation coefficient. If the values of the two variables change in the same direction, (for example the demand for a given ship type increases as the level of supply of the ship type increases), then this is a positive correlation and if the variables change in the opposite direction (e.g. if supply for a given ship increases and the demand falls), then this is called a negative correlation i.e. a negative correlation does not mean "no correlation" rather it indicates the direction of correlation.

6.2 Regression

Regression is the 'best line of fit' for correlation as it focuses on developing the best line of fit to predict future events and variations. This method has been used extensively in the development of forecasting models. Before the emergence of neural network techniques it was considered an accurate and reliable method to extrapolate future values for a variable in linear and near-linear cases. It is still being used in many applications (11.16).

7 ARTIFICIAL INTELLIGENCE (AI) METHODS

7.1 Expert Systems

Computer and software-based technological developments have created opportunities for the creation of expert systems, (18, and 19), where examples include autopilot of airplanes, operation of power stations and within the maritime industry many aspects of navigation, engine control and docking and berthing operations make use of such systems. Attributes of expert systems, for instance their self-corrective capabilities, have applications when developing forecasting models for predicting the supply of ships. Existing forecasting models that make use of neural networks, currently do not have such facilities for instance in case of discontinuities or sudden changes occurring in demand and/or supply trends. The model developed in this programme of research provides measures for sudden changes and a corrective system for recovery when such changes occur.

7.2 Neural Networks

Artificial neural networks are a family of numerical learning-based techniques. They consist of non-linear computational elements which form the network nodes or neurons, linked by weighted interconnections (9) compares neural networks to the neurological systems in animals, with neural networks made up of artificial neurons. He argues that artificial neural networks are much simpler than biological ones. Nevertheless, he is of the view that they can perform certain tasks, particularity classification, most effectively. The major reason for their popularity and recent prominence is that neural networks are basically learning mechanisms which are capable of handling large amounts of data and are able to provide reliable outcomes provided the network is carefully constructed, trained and tested. This ability to learn from a 'seemingly large amount of abstract data and to interrelate different sets of information' makes them an ideal tool for use in forecasting (17.19,22)From the basic structure of a neural network (NN), as illustrated in Figure 2, more complex forms of NN have been developed including the Cellular Neural Network (CNN). Illustrated in Figure 3 these networks types are better suited for the solution of specific problem types where the nature of the problem is cellular, such as in image recognition. In this respect a reported advantage of CNN is stated as the speed at which models can be developed. A review of CNN indicated that these types of neural networks are not suitable for predicting future capacity for various types of ships and that ANN are more appropriate networks for development of a prediction model.

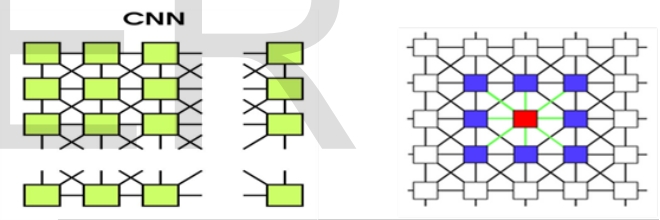

Figure 2: A CNN Structure Representation

The supply values for different types of vessels including for bulkers are purely time series and conventional time series forecasting techniques and artificial neural networks are the main means of predicting future trends based on passage of time. A study by (17, 21) reported that developing models to describe relationships in real life requires accurate and effective forecasting tools. In line with many other researchers they emphasize that real life processes are often non-linear in nature. They argue that it is not possible to describe such processes using conventional prediction methods such as regression and correlation analysis. They argue that little research has been done in developing forecasting methods for non-linear processes where they refer to the work of (16). Such arguments previously reported by (19) and (21) who stressed the need for future research on developing solutions with an emphasis on making their use more practical. These researchers reported that, some 20 years later, non-linear forecasting is still not widely applied despite considerable theoretical advances in this subject. The reason for

such a slow progress is provided by (20), stating the lack of empirical research on forecasting methods and software solutions that are easy to use. The experimental work will be illustrated in details in in the following research paper.

8 RESEARCH METHOD

Review of the work carried out in the thesis clearly indicates that the task of reviewing the current forecasting techniques and identifying the most effective methods were carried out as expected. The research identified the most effective forecasting technique which was the neural network model developed in this thesis. Also the work concerning relationships between supply and demand for shipping with a view to explore the nature and the strengths of these relationships were carried out as planned. It was noted that there is a very strong relationship between supply and demand hence providing a means of accurately estimating the demand values from predicted supply values for different types of ships. The shipping trade primarily depends on cargo that needs to be transported (i.e. demand) and ships available to transport the cargo (i.e. supply). Recent statistics, presented in Table 1 (7), clearly show that sea trade is increasing on a global basis. Since 1980 the total world fleet has increased from 619.2 million dwt to 762.2 million dwt in 2003 and to 1,292.1 million dwt by 2010 (Shipping Intelligence Network, 2010)

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total World Fleet (TWF) million dwt (x)	565.3	562.10	561	570.1	586	603.2	615.7	624	613.4	633.8	651	665.8	685.1	696.2	706	725	742	762.2
World Seaborne Trade (WST) million tonnes (y)	3,630	3,629	3,900	4,166	4,151	4,190	4,325	4,528	4,641	4,800	5,048	5,318	5,321	5,446	5,705	5,840	5,894	6,149
Normalised TWF	0.74	0.74	0.74	0.75	0.77	0.79	0.81	0.82	0.80	0.83	0.85	0.87	0.90	0.91	0.93	0.95	0.97	1.00
Normalised WST	0.59	0.59	0.63	0.68	0.68	0.68	0.70	0.74	0.75	0.78	0.82	0.86	0.87	0.89	0.93	0.95	0.96	1.00

Table 1 Total World Fleet million dwt (8)

The lead-time in designing and producing a vessel, as well as planning resource requirements for its management and operation, is normally 18 months. As stated earlier, by the time the ship is built and put into operation, the situation in the maritime market could be very different than when the decision was made to build the ship. The data provided in Table 1, (Shipping Intelligence Network, 2004) shows that supply and demand are not standardised across different types and designs of ships. The review of the shipping market shows that while the demand for a given type of ship could increase in a given period, the demand for other types of vessels could decrease in that same period.

9 FORECASTING CAPACITY

The research here identified comparisons of forecasting methods. Table 2 shows the accuracy of the four forecasting techniques for a given type of ship, i.e. bulkers. As shown the neural network model is the most accurate with an average percentage error of 0.23 of which is approximately half of the average errors of the other three methods. Figure 9 is the graphical presentation of neural network predicted values against actual supply values for bulkers.

Table 2 Comparisons of forecasting methods

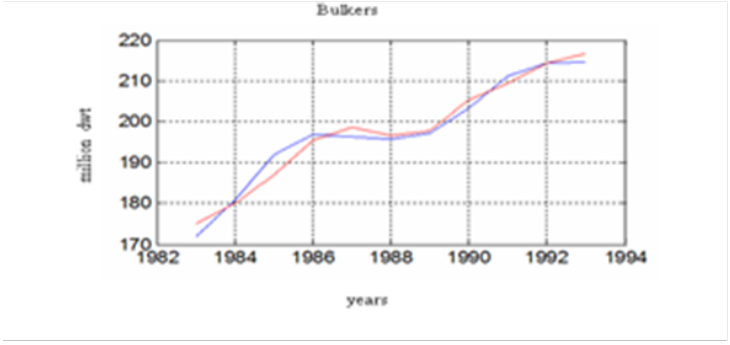

Figure 3: Actual capacity/demand versus NN forecasts of Trends for Bulkers to develop an accurate and reliable method of forecasting supply for various types of ships.

FORECASTING METHOD	MAX NEGATIVE % ERROR	MAX POSITIVE % ERROR	AVERAGE % ERROR
CORRELATION	0.00%	0.51%	0.50%
REGRESSION	-1.78%	0.26%	-0.45%
SEASONAL VARIATIONS	-1.78%	0.36%	-0.40%
NEURAL NETWORK	-0.58%	0.78%	0.23%

10 CONCLUSION

Review of the work carried out in the thesis clearly indicates that the task of reviewing the current forecasting techniques and identifying the most effective methods were carried out as expected. The research identified the most effective forecasting technique which was the neural network model developed in this thesis. Also the work concerning relationships between supply and demand for shipping with a view to explore the nature and the strengths of these relationships were carried out as planned. It was noted that there is a very strong relationship between supply and demand hence providing a means of accurately estimating the demand values from predicted supply values for different types of ships. This later work successfully concluded the work intended in task 3 of the research programme. The development

of the forecasting model and, system for data collection and analysis on a daily basis will be illustrated in Part B of this paper. ,

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