ABSTRACT

CONTAINER ARRIVALS FORECASTING: PRACTICE AND EXPERIENCE AT MARINE TERMINALS

by
Alexios C. Sideris

The advent of the container traffic in maritime transportation has led during its 40-year long history to novel perceptions and operation planning requirements for the port container terminal. A major requirement in this respect refers to the efficiency of the operations in the container transfer between the different modes. The current study presents a methodology on the development of a forecasting tool to access the service demand patterns at a marine terminal on per day basis. A set of forecasting models was introduced and their implementation difficulties were explored. The main effort in this approach was to replicate the distribution of container arrivals/pick-ups before and after the scheduled voyage date of a vessel. A data-driven decision support system was developed to retrieve and to analyze the historic information captured at a major terminal of the U.S. East Coast for a period of 18-months. The evaluation of the current solution revealed a satisfactory fit of the forecasting model projections to the actually observed patterns. Due to the lack of a solid theoretical background, the approach is unfavorable to the use of applied statistical tests. In general the product should be seen as a management information system designed to assist the terminal activity planning and equipment management in conjunction with the coherent experience of the operating team.

Container Arrivals Forecasting: Practice and Experience at Marine Terminals

by

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A Thesis
Submitted to the Faculty of
New Jersey Institute of Technology
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Transportation

Transportation Committee
Interdisciplinary Program in Transportation

January 1999

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This thesis is dedicated to

Théodore Géricault (1791-1824)

for his inspiring work “Le Radeau de la Méduse”

ACKNOWLEDGEMENT

The author wishes to express his sincere gratitude to his advisor Dr. Lazar N. Spasovic for his most valuable guidance and help throughout the course of this thesis. The author is indebted to Dr. Spasovic for his encouragement and moral support. Many thanks for your patience and for making our collaboration at NJIT an invaluable learning experience.

Special thanks to Dr. Athanassios K. Bladikas and to Dr. Xiuli Chao for serving as members of the committee.

The author appreciates the critical support provided from Maher Terminals Logistic Systems Inc. Extended thanks to Dr. Roger E. Nortillo, President of MTLS Inc., to Mr. Nicholas P. Arlea and to Mr. Laurence Perez for their notable help and guidance in data collection efforts.

The financial and educational support of the State Scholarship Foundation of the Hellenic Republic throughout the entire period of study in the United States of America is specially acknowledged.

Finally, many thanks to the members of my family and my friends for their confidence and moral support all these years.

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Chapter One

INTRODUCTION

Container traffic has been growing steadily since the introduction of containerized cargo ships in the 1960s. In recent years, a significant portion of this growth has been due to the increased demand for intermodal services, where containers are transported by ships, trains, and trucks. As defined by the National Commission of Intermodal Transportation, intermodal service, in general, refers to the "interconnections among modes of transportation" and the "use of multiple modes for a single trip". Current reports show that the intermodal share accounts for one quarter of the total container moves at the U.S. East Coast and for over half at the U.S. West Coast. (US.DOT, 1998) The essence of intermodalism is to use the most efficient and economical transportation mode (e.g., ship, rail, or truck) to cover each part of the journey. The intermodal problem is not so much a challenge along the line-haul portion of the trip, but rather in designing and executing the interface points between the modes. Since more than 80% of the international trade is moved by ships, marine terminals are highly ranked in the transportation network interface. Therefore, it is the key-role of the marine container terminal to perform its objectives in the most efficient way.

From the economic point of view, the issue is considerably complicated since ports authorities are operating in a dramatically changing business environment imposing major dilemmas on the strategic decision process. Presently, their growth and development is substantially governed by external economic factors and this situation will continue in the foreseeable future. Thus, ports are expected to compete in today's world market environment to keep and improve their position. The terms governing this competition, since they are set through a business environment consisting of several different participants, are difficult to be tracked and are not the scope of this study.

However from the operational perspective, container terminals are seeking to excel in their function as transportation nodes in order to preserve their ability to compete successfully in the market environment. That is to be achieved within the context of the most efficient usage of the available capital and technology resources. Indeed the last decade has been a period of revolutionary changes in these sectors for the U.S. container terminals. This distinct progress has been triggered by a conjunction of different factors. Among those that should be emphasized are the deregulation of the transportation sector, technological developments in hardware and equipment, improvement in logistics systems, and the availability of modern information systems and information technology. (Veras, 1996) Despite the unparalleled success in implementing these innovations, it should be noted that the majority of them are focusing on the supply side. That involves optimizing the overall throughput of the terminal by inducing better performance in particular operating practices. Yet the speed of this change, the relative cost reduction in information technology along with other industry indices have inadequately diminished the more managerial aspects of improving the quality of service through effectively responding to the actual needs and harnessing in a sense the demand for services.

1.1 Problem Statement

To clarify the purpose of the research a brief description of the basic marine terminal operating functions is presented hereinafter. The marine container terminal is the place were the containers received from ocean vessels are transferred to land carriers, such as trucks, trains, or canal barges and vise versa. Thus, it is a major node in any intermodal transportation network.

A typical marine container terminal performs four basic functions: receiving, storage, staging, and loading. All four functions must be performed for all containers, whether they are imports (and thus enter the terminal by a ship and usually leave by land) or exports (and thus usually enter the terminal by land and leave by ship).

Receiving is the function of recording the arrival of an export or import container at the terminal and capturing the relevant information about the container. Storage is the function of placing the container on the terminal in a known and recorded location so that it may be retrieved when it is needed. Staging is the function of preparing a container to leave the terminal. For example, an export container may be staged at the time of initial storage, or it may be moved from its initial location to a second location with other containers for the same ship. In other words the containers that are to be exported by the same vessel voyage are identified and organized so as to optimize the ship loading. Import containers have similar requirements, except fewer containers will generally move out of the terminal together. Finally, the loading function involves placing the correct container on the ship, the truck, or other modes of transportation. (Chadwin, 1993)

In addition to these four basic activities, other functions may take place on the terminal. Some containers may be loaded or unloaded ("stuffed" or "striped" in industry lingo) and usually this is done at a terminal facility, such as a warehouse or container freight station (CFS).

All the prescribed functions require the actual spatial movement of containers within the terminal. To facilitate these transfer movements between the vessels and the land modes through the storage area, special equipment is utilized. Among the most common types of storage organization is the use of tractors pulling chassis to and from the slots area and transtainers to lift the container into and out of the stacks. Or similarly straddle carriers than can both transport the container from place to place and also stack it in layers are used. In both cases, the equipment used has a quite high ownership cost as well as operating (annual maintenance, wear and tear). For example the average annual cost of a modern straddle carrier including capital amortization cost and labor is currently in the range of $700,000. Thus, it is perceived that a high utilization factor should be achieved to justify the investment. This can be accomplished if an essential piece of information describing the overall daily demand for moves and for each operation or function respectively is acquired. With the exception of dedicated terminals operated by ocean liners (e.g. Sea Land) most of the ports provide service to several different customers. Due to the competitive environment aforementioned, the port does not have any direct influence on shipper decisions with respect to time scheduling of shipment. Moreover, the shippers may not be willing to reveal their strategies to third parties. Thus, since the terminal operator has limited access to the pertinent information, the forecasting techniques are more suitable in dealing with service demand.

1.2 Research Objective

In this thesis, a simple process of obtaining the required information to forecast the service needs at a container terminal and to support the management decisions with regards to operational objectives, is examined. The benefit of this process would be a formalization of the knowledge on demand patterns allowing for a more consistent usage of the existing resources.

Every container entering the port is in most cases associated with a scheduled voyage of a particular vessel. The export containers aimed for a certain voyage are entering the terminal following an arrival time-diagram. Similarly the import containers after being unloaded from the containership are removed from the terminal and the process follows a pick-up time-diagram. Thus, the in-port traffic demand for that voyage may be described as a distribution of daily container arrivals before and pick-ups after the ship call at the port. Having this information the total number of arrivals for a certain day of operation can be estimated. This is done simply by aggregating the estimated arrivals/pick-ups for that day of the multiple voyages that occurred in the proximity of that day. The number of container arrivals can then be used to estimate the actual need for processing moves by the specialized equipment.

It should be emphasized that the present study focuses on the short-term operational aspects of the container terminal and its purpose is not to provide insight into the general planning process of marine terminal development and expansion. Therefore, the followed approach differs substantially from the applied research targeting the estimation of the capacity of the terminal in terms of land requirements and the preferred storage area organization. Since 1970's several models have been developed to address these issues. In many cases there were incorporated into actual cases with varying credibility. Two different techniques are adopted in these models to assess the critical time the container stays in the terminal. In the more analytical instances, usually an average value is used with the introduction of additional factors to make up for seasonality effects and other trends. (Nilsen 1977, Frankel 1979) Another technique more widely adopted by simulation models is the use of a general predefined time-diagram for the container arrivals. (Rijsenbri 1983, Groenveld 1991) In both cases the goal is to construct a cumulative distribution of the container inventory level and estimate the probability of exceed at a certain level of significance. This procedure attempts to estimate the required number of container slots considering a preferred occupancy ratio. Despite the usefulness of those models in depicting the operational characteristics of the terminal over a long period of time, their practical value is diminished in the concept of daily demand forecasting. A careful investigation reveals that the adoption of the cumulative distribution to describe the mechanism of container arrivals/departures, has a smoothing effect on the intense daily variations of the traffic at the terminal. Hence, although the extracted distributions are more suitable, allowing the good fit of theoretical distributions, in the same time are concealing the underlying peeks and valleys characterizing the shape of the daily demand distribution. (Ballis 1995) For that reason the findings of those models are not suitable for the tactical planning.

In conclusion, the proposed technique will attempt to ascertain the daily demand patterns, by providing a tool to explore the discussed variations. Except of the prudent equipment management, additional benefits will be the evaluation of the truck gate requirements and the investigation of possible terminal congestion.

1.3 Scope

This research focus on intermodal container staging operations at a major marine terminal located in Port of Newark/Elizabeth in New Jersey. The primary objective is to determine the applicability of demand forecasting techniques based on existing historic information. A private company operates the terminal under investigation. The logistics group of the company provided all the required data and assisted in defining the critical parameters to be incorporated in the envisioned forecasting models. The data used in the final product cover the existing conditions at the terminal for a period of 18 months.

1.4 Overview

This thesis is organized as follows. Chapter 2 deals with the particular issues of demand forecasting analysis at a container terminal. Chapter 3 presents the practical experience on the development of a managerial tool designed to assist the forecasting techniques presented in Chapter 2. Chapter 4 deals with tool evaluation and presents selected case studies. Chapter 5 presents conclusions and recommendations for future research.

CHAPTER TWO

CONTAINER ARRIVALS FORECAST MODELING

2.1 Distribution of Arrivals/Departures Over Time (General Pattern)

The critical point in the successful development of the forecasting techniques is to acquire a reliable model for the distribution of the container arrivals during the terminal operation. This distribution pattern is directly linked to the particular scheduled date of voyage arrival.

2.1.1 Analysis on Per Vessel Basis

The first important decision, is the identification of each particular vessel as a unique entity of the model. That clearly implies that for any containership scheduled to call at the port an indexed proper container arrival/departure pattern is needed.

Certain attributes and practices that characterize the recent developments in the ocean container transportation favor this approach. First of all the size of the containerships is steadily increasing leading to a "hub and spoke" system similar to the one widely adopted by the airline industry. It is projected that by the year 2010, almost 30% of U.S. containerized cargo will be handled on ships in the 4,000 to 6,000 TEU class, with more than 9% in the 6,000 to 8,000 TEU class. In comparison, less than 6% was handled on ships of 4,000 TEUs or more, in 1990. (US.DOT, 1998) This observation calls for a fixed arrival schedule for the containerships servicing exclusively predetermined routes. That is quite true for most of the main terminals as the major shipping lines are scheduling frequent calls of the vessels servicing a certain number of ports in a sequential and steady manner. Moreover the shipping alliances by initializing space pact contracts in order to maximize their utilization factor, are favoring this operating scheme. Finally the big modern container ships incur a high operating cost, and the container shipping lines are seeking to maximize the productive time of operation. As a result, there is always a pressure to the terminals for immediate and quick service time. Taking into account the terminal operator response to this demand within the industry's competitive environment, it is observed that in most cases the vessel in-port time has been reduced to a maximum of two days.

All these considerations are fortifying the selection of the specific voyage as the critical event in the terminal operation, ensuring the formulation of the daily demand patterns accordingly to vessel arrival and departure dates.

2.1.2 Time Step for the Analysis

Another point that requires careful consideration in any forecasting model is the preferred level of analysis with respect to the basic time unit. In the current study, the time-step was selected to equal to one day of operation. The rationale for this is that in maritime industry the ordinary business practices are usually planned on a time horizon split in working days.

2.1.3 Demand Pattern Configurations

The next important step is to determine the time frame, namely the period before and after the specific voyage arrival. The most recent studies dealing with the estimation of the required terminal capacity indicated that the container dwell time in U.S. ports averages 6 to 8 days. (US.DOT, 1998) In general, export containers tend to have a shorter storage time, since are targeted toward a particular vessel with a scheduled sailing date. Shippers will normally schedule containers to arrive at the terminal as close as possible to the sailing date. Import containers, on the other hand, arrive on a schedule, but usually do not have as rigid a schedule for pick-up by land modes (with the exception of on dock unit trains). Some shippers may dwell containers in a port because simply it does not cost them anything to store them there. Customs and other regulations may cause additional delays in some cases. An initial crude statistical examination of data provided to the authors by a major terminal of the U.S. East Coast allowed more quantifiable results with respect to the aforementioned objectives. The analysis showed that in a significant number of voyages the 90% of transactions both for the export and import sector, were completed within a time span equal to ten days of terminal operation before and after the voyage date respectively. The export containers appeared to be slightly more concentrated towards the vessel departure day. In addition, it was observed that beyond and after this 10-workday period the container arrivals were rather random and thus the formulation of a statistical model to describe them seems unrealistic. For these reasons, the time was set at 10 work days.

2.1.4 Different Types of Movements

The initial data analysis not only provided a reasonable interval for the distributions modeling but also revealed certain dissimilarities in the patterns associated with the different transportation modes. Generally, ports that receive containers mostly by truck tend to have higher dwell times, while ports with on-dock rail service tend to have lower dwell times. The intermodal moves usually have a shorter dwell time averaging less than three days. Additionally, the moves are grouped in larger quantities. For example, a unit train combination with double-stack cars may carry up to 400 boxes inducing high peaks in the land-side demand. The operation of units trains is rather fixed and although the intermodal transfer-terminal may not be on-dock or within the port area, the terminal operator has a satisfactory knowledge of the schedule. However, the intermodal split differs substantially among the vessels and the investigation of the percentage moved by rail is very important from the operational perspective. Therefore, on the development of forecasting models it was found as critical to discriminate among the different types of movements.

For the export section four types of movements are defined:

- Arrived by truck: It is the most common way of transportation for containers originating in the immediate area of the port and in radius up to 200 miles.
- Arrived by rail: Includes the unit-train (express rail) operations.
- Stuffed in port: Defines the portion of containers packed in the terminal to serve multiple LCL (less than container load) shippers.

- Transshipments: Containers arrived by a previous voyage and are transferred to reach their original destination. Though these containers do not pass through the terminal gate, they are temporarily stored and thus require handling operations.

For the import section three types of movements are defined:

- Picked-up by truck: The final destination is in the vicinity of the terminal or within a reasonable distance from it (up to 400 miles).
- Striped in port: Defines the portion of containers unpacked in the terminal to ship the goods to the final consignee in the case of LCL shipments.
- Transshipments: Containers with a faraway final destination that are to be transferred to another ship or to rail. The exact date and vessel of re-shipment may not be known at the time of unloading.

2.1.5 General Vessel Profile

Having on hand the prescribed distribution patterns for multiple voyages of the specific ship makes it feasible to construct a generalized model that will be used as a generic-forecasting tool. We would rather calculate a weighted average of the daily demand patterns, to count for the different absolute shipment volumes of the historic voyages. In that way, a proportional magnitude of each voyage would be incorporated in the model. In the situation were a vessel is switched to alternate and/or reverse routes that have significantly different characteristics, it would be appropriate to construct more than one models depicting the intrinsic effect of these changes. For example, consider a scheduled trip originating from a West-European port calling at several main U.S. East Coast terminals following a southbound route. On the return trip, a northbound route will be probably followed. Thus at the port of focus, it is critical to know the direction of the specific voyage route.

2.1.6 Further Considerations

A final thought, with regards to the distribution model requirements, would have been an effort to link the demand pattern to the specific content of the containers that are to be unloaded or loaded to a particular vessel. Especially for the import section, it is highly reasonable to assume that the demand patterns may be correlated to the actual value or properties of the goods stored in the containers. For perishable products or for high-valuable goods it is expected that the owner would opt to pick-up the container at the earliest possible time after unloading to minimize damage or inventory costs. On the other hand for low-value commodities a consignee may prefer to use the terminal slot for temporary storage. That is quite true since the profound easiness and practical advantages of containerization, along with the reduction in operating costs calls for high usage of containers even for less-valued goods. Whichever the case, again from the realistic point of view, despite the meaningfulness of such an approach, it is noted that the related information is not readily available to the terminal. Due to deregulatory issues as long as international trade treaties to speed the transportation process, with the exception of hazardous materials or military equipment, the terminal operator does not have formal knowledge on the container contents. However, the proposed method of analysis by identifying the individuality of each vessel/voyage abridges conceptually this missing instance. It is asserted that since the vessel is assigned to serve a particular route, it is quite probable that the mix and type of the goods classification remains constant for each subsequent voyage over a long period.

2.2 Forecasting Models

The main denominator in the presented methodology was to construct a model directly linked to the terminal information system. The initial effort was the development of a tool, with the capability to formalize and present accurately the current patterns by utilizing the logistics system information. That decision was driven by the need to reserve as much as possible the practical value of the existing data. Therefore, the tool is designed to assist the terminal operator's current decision process based on experience, rather than substituting it with a solid theoretical model. In the context of the particular industry traditional aspects, since the problem has a very practical nature, this approach, though it lacks an underlying theory, it possesses a worthy flexibility.

Three different models are envisioned. They differ in the amount and quality of data required.

2.2.1 Model I

The first model is quite straightforward and it simply replicates historical situations. The necessary information is limited to the estimated voyage date at the port for a particular vessel. Then the terminal operator by retrieving the corresponding daily demand distribution will be able to estimate the number of arrivals for the current date presumable that there are less than ten operating days before or after the voyage arrival. The demand pattern is developed by combining previous voyages of the specific ship in a general model.

An important issue is how far in the past the model should look. In other words, what is the number of past voyages to optimize the forecast. Since, each vessel has different characteristics, there is no general answer. At this point, the experience of the terminal management team should be applied. More specifically, the operator should decide which voyage is more probable to have similar patterns to the current, so as to be included in the model. However, regardless of the data availability, the most recent voyages should be the first candidates, whereas voyages, which occurred more than a year ago, are less reliable.

The final task for the forecasting tool is to aggregate the derived estimate of arrivals/departures for the current date and for all the subset of voyages associated with.

2.2.2 Model II

Model I implies that the total demand for the current voyage is generally unknown. As a result, an estimate of the total number of arrivals should also be derived by the historic data and then distributed over the operating dates. A direct enhancement to improving the forecast would be the consideration of the total actual number of containers for the current voyage rather than an estimate based on the average of previous voyages for that vessel. This second model requires knowledge of the expected arrivals for the current voyage in addition to the demand distribution pattern. In this instance the derived model represents a conditional probability distribution expressing the probability $P(x/i)$ that a container will arrive in day x given that there are i days before the scheduled voyage date.

Multiplying these probabilities by the total expected number of exports or imports respectively provides actual estimates on the demand pattern.

For the import section the expected number of containers is in general readily available since the shipping companies are required to inform the port in advance on the containers arriving on a specific voyage and are to be unloaded. A direct summation will be sufficient in acquiring the total expected number.

For the export section, the problem is more complicated since the required total demand can only be estimated by inquiring the shipping brokers. This will require an extra effort to be taken by the terminal operator, but it certainly provides an improved forecast compared to the one obtained by the first model.

2.2.3 Constructive Example

To illustrate the tool application an example is presented at this point. Consider that three voyages namely A, B, C, are scheduled within a period of 10 days from the current date. Table 2.1 summarizes the required information to apply the forecasting tool. Consequently, Table 2.2 records the distribution pattern of the remaining demand for each voyage respectively. Finally in Table 2.3 the actual daily demand patterns are calculated and aggregated for all three voyages in total units per day.

Table 2.1 Voyage Information

	Days before Voyage	Expected Units per Ship
Ship A	6	1000
Ship B	8	800
Ship C	10	900

Tables 2.2 Conditional Probability of Export Container x entering port given the number of days i before the Voyage Departure. (Distribution Pattern)

	Days before Voyage (for Ship C)											
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	Total	Units/Ship
Ship A	0.05	0.07	0.11	0.14	0.19	0.12					0.68	1000
Ship B	0.03	0.04	0.05	0.08	0.12	0.16	0.21	0.18			0.84	800
Ship C	0.01	0.03	0.04	0.06	0.08	0.11	0.15	0.21	0.18	0.13	1.00	900

Table 2.3 Total Number of Export Containers entering port for each Day of Operation

	Days before Voyage (for Ship C)											
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	Total	Units/Ship
Ship A	50	70	110	140	190	120					680	1000
Ship B	24	32	40	64	96	128	168	144			696	800
Ship C	9	27	36	54	72	99	135	189	162	117	900	900
Units/Day	83	129	186	258	358	347	303	333	162	117	2276	2700

In the example it is assumed that a portion of the total demand for ships A and B has already arrived since there are less than ten days left until their respective arrival date.

For the import section the model application is identical.

Figures 2.1 and 2.2 depict graphically the examined situation.

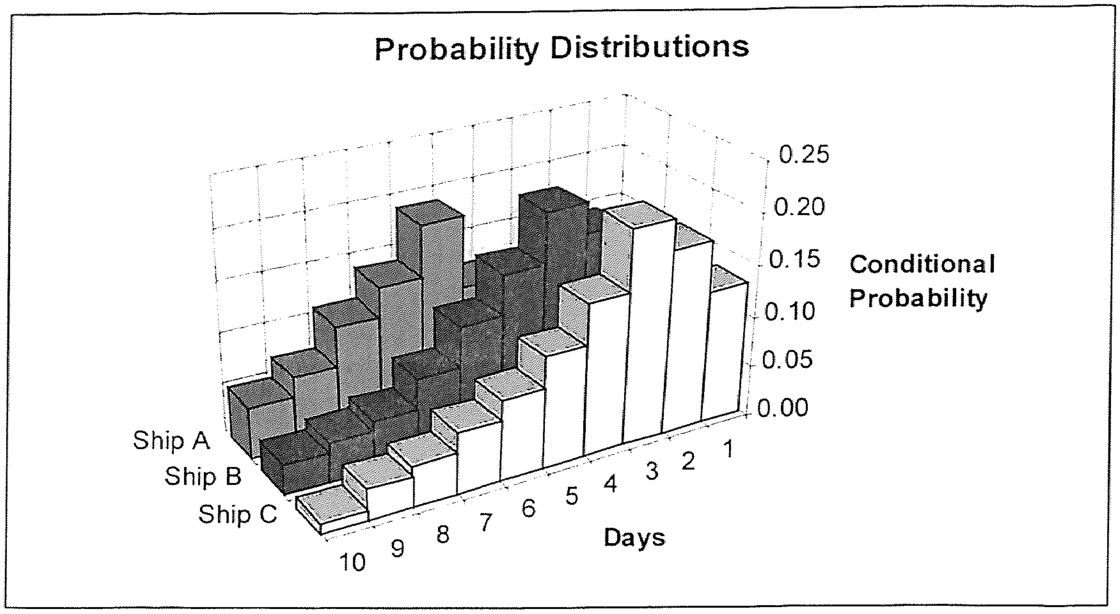


Figure 2.1 Demand Distribution Pattern (based on a 10-day profile).

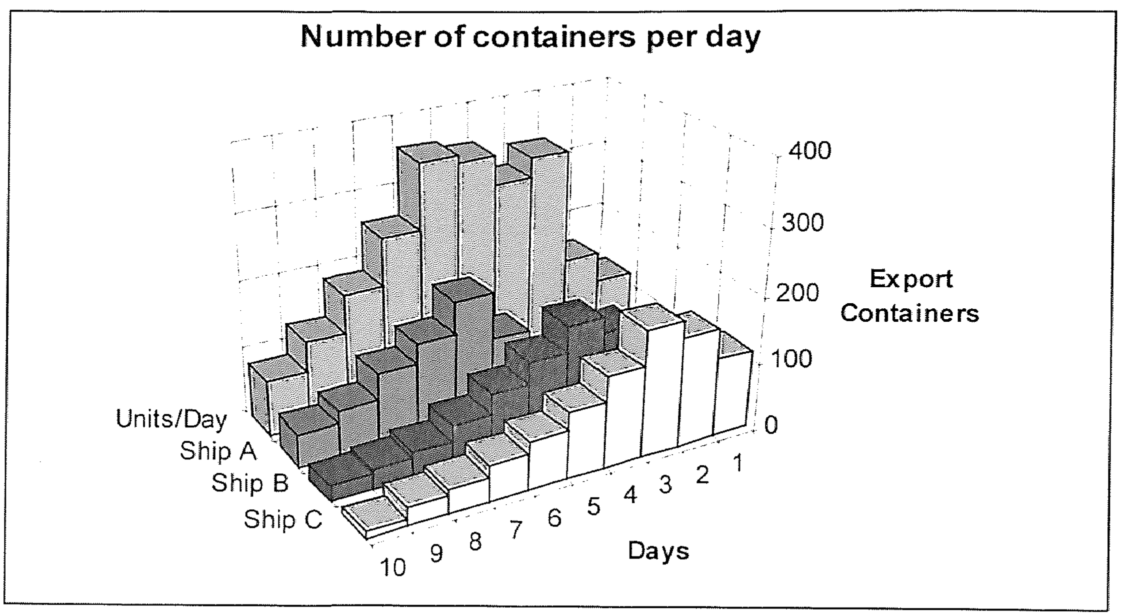


Figure 2.2 Actual Daily Demand

2.2.4 Model II+

Further enhancement to this model would require a more dynamic approach. That is by means of assessing information on the progress of the arrival/departure process in real time, while in the critical time period for the specific voyage. For any day of operation, all the gate movements are recorded in full detail for logistics purposes. The terminal control not only has complete knowledge on the number of containers that remain in the storage area at the end of the operating shift. It can also track any individual box through its unique alphanumeric code. Therefore by inquiring the current inventory for a specific voyage it is easy to verify the number of export containers that have not yet entered the port to be stored, i days before the vessel arrival. This is done by subtracting the number of those arrived from the total expected estimate. Similarly, the number of import containers still in the port, i days after the voyage date is verifiable. Then, this real-time information is cross-checked with the forecasted estimation provided by the model. The positive or negative deviations of the expected values from the actual contour are consequently used to re-adjust the demand distribution. The dynamic nature of this approach rises from the requirement for continuous correction in allocating the remaining containers.

CHAPTER THREE

MODEL IMPLEMENTATION

The remaining of the present study explores the applicability of developing the proposed methodology in the representation of an actual terminal operation. The data where provided by Maher Terminals Logistic Systems Inc. Maher Terminals Inc. operate two of the marine container terminals located in Port of Newark/Elizabeth in New Jersey. The data files provided are for the Fleet Street terminal. The terminal has 10 ship berths and the total area is in excess of 500 acres. The containers are stored in several on-dock stack areas and they are moved by straddle carriers.

3.1 Data Evaluation

The main file supplied by the Maher Terminals logistic system is called "History File" and contains records on all export and import container movements. The data set covers an eighteen months period of operation and includes approximately 300,000 loaded container moves. About 55% of the transactions are imports including transshipments. The remaining 45% make up for exports. The moves associated with empty containers where not taken into consideration in this study and where eliminated from the original file.

3.1.1 Data Manipulation

In the database, each container movement through the port is captured by two separate time records/events. The first event represents the container entering the port (In Event). The second event represents the container exiting the port (Out Event). Table 3.1 summarizes the essence of the In & Out Event for export and import containers respectively.

Table 3.1 Events Definition

	In Event	**Out Event**
Import Container	In by Ship	Out by Truck/Rail or Striped in Port
Export Container	In by Truck/Rail or Stuffed in Port	Out by Ship/Rail

To evaluate the time specific characteristics of each container movement and particularly the duration of stay in the terminal the two records were merged. Several intrinsic difficulties aroused at this point primarily due to the multiple appearance of the containers throughout the examination period. A logic-based technique was developed to link correctly the associated events by taking into account certain date and time relational criteria. Any redundant or orphan records were not taken into consideration.

Appendix A comprises an overview of the necessary record handling and the subsequent record file manipulation.

3.1.2 Voyage Date Definitions

A more critical inhibition in using the existing data, was the lack of formal knowledge regarding the voyage date. The "History File" simply does not record the actual date of ship arrival/departure at the past. The file does however include for each record an identifying voyage code.

In order to record the dwell time for each container, every export or import container has to be associated to a specific voyage and its respective voyage date. The voyage date must be derived. A practical way to overcome this difficulty was to derive an approximation of the voyage date by correlating the records to each other. For the export movements, the voyage date is approximated by the loading date/time of the last container. It is assumed that the ship sails out shortly there after. For the import movements, the voyage date is approximated by the date/time of the first container unloading. In order to unload containers the ship had to arrive first. The loading of export containers is assumed to be completed within a period of two days before voyage. The discharging of import containers is assumed to be completed within a period of two days after voyage. The only limitation of this approach is the need to restrict the wharf operations within a certain time period. These necessary assumptions, in order to group the records, are not in fact restrictive since the short wharf time is very common in the containership industry. Each minute that a large containership sits at a terminal being loaded and unloaded may cost the ship line $100 or more. (Chadwin, 1993) Therefore, an effort is taken to eliminate the in port delays. The experience at Maher Terminals showed that at the vast majority of the voyages, the wharf transactions were completed certainly within the two days period. However, a main disadvantage of the proposed technique is the possibility of estimating a different voyage date for the exports and imports respectively. That leads to the necessity of keeping independent and separate the export and import section. Until formal information on the voyage date becomes available, the model separation is unavoidable.

Further complication is caused by the fact that the available voyage code is not reliable for the purpose of assigning the containers to a particular voyage. For the outbound voyages, the shipping companies are using different codes for the same trip. Moreover, the same voyage code is used for multiple voyages distant in time. So though it is used for verification purposes, it is not suitable for the original grouping of the data.

3.1.3 Necessary Conversion

Finally, an important issue in utilizing the existing data was the fact that the time-related fields of the original file were referenced in an actual time context rather than in days of operation. Although, the wharf operations are usually continuous with several shifts around the clock, the land-side gate is manned during the weekdays only. The records included in the "History File" are suitable for recovering individual historical voyages. However, the obtained demand distribution is based on the actual dates before and after the voyage. This includes the non-operating periods such as weekends and holidays. According to the model description, the general demand profile of each ship is derived by referring to multiple voyages. Consequently, it was important to convert the demand patterns in an operating time basis to neutralize them from the distortions caused by the weekend idle time. That suffices the need of a common denominator, and allows the inclusion of the multiple voyages in a single general profile.

3.2 Management Information System (MIS)

For the successful application of the described forecasting tool, a major requirement is the quick, on-line access to accurate information. The prescribed demand patterns should be readily available on the demand of the terminal management team. That implies the need for the development of a management information system. The system must have the maximum possible level of accuracy and interactivity.

In this section is presented a brief review of the database system that was developed as a tool of acquiring and displaying the related to the forecasting models information. The system is built on form-layers, each layer being accessible from another by means of a defined button click. A consistent and carefully designed layout facilitates the requirements for ease of use and self-documentation.

The system is developed in the `Microsoft® Access 97`, database environment and runs under `WindowsNT®`. The source code is written in `Microsoft® Visual Basic for Applications (VBA)`.

The database program is capable of importing directly the 'History' files provided from the terminal in text format. This feature suffices the need for frequent data updating to include the most recent voyages.

Two similar but separate analytical modules are available for the retrieval of information for the export and import sector respectively. Those modules facilitate the concurrent analysis of past voyages for a particular vessel.

Finally, a module provides additional functionality through a process of forecasting the total daily demand for a given sequence of scheduled voyages and corresponding shipment loads.

Figure 3.1 shows the main form of the developed MIS system.

The remaining of this chapter focuses on the implemented controls and functions demonstrating the possible analysis level provided by the system. A detailed technical report on the database development and programming features and objects is relegated in Appendix B.

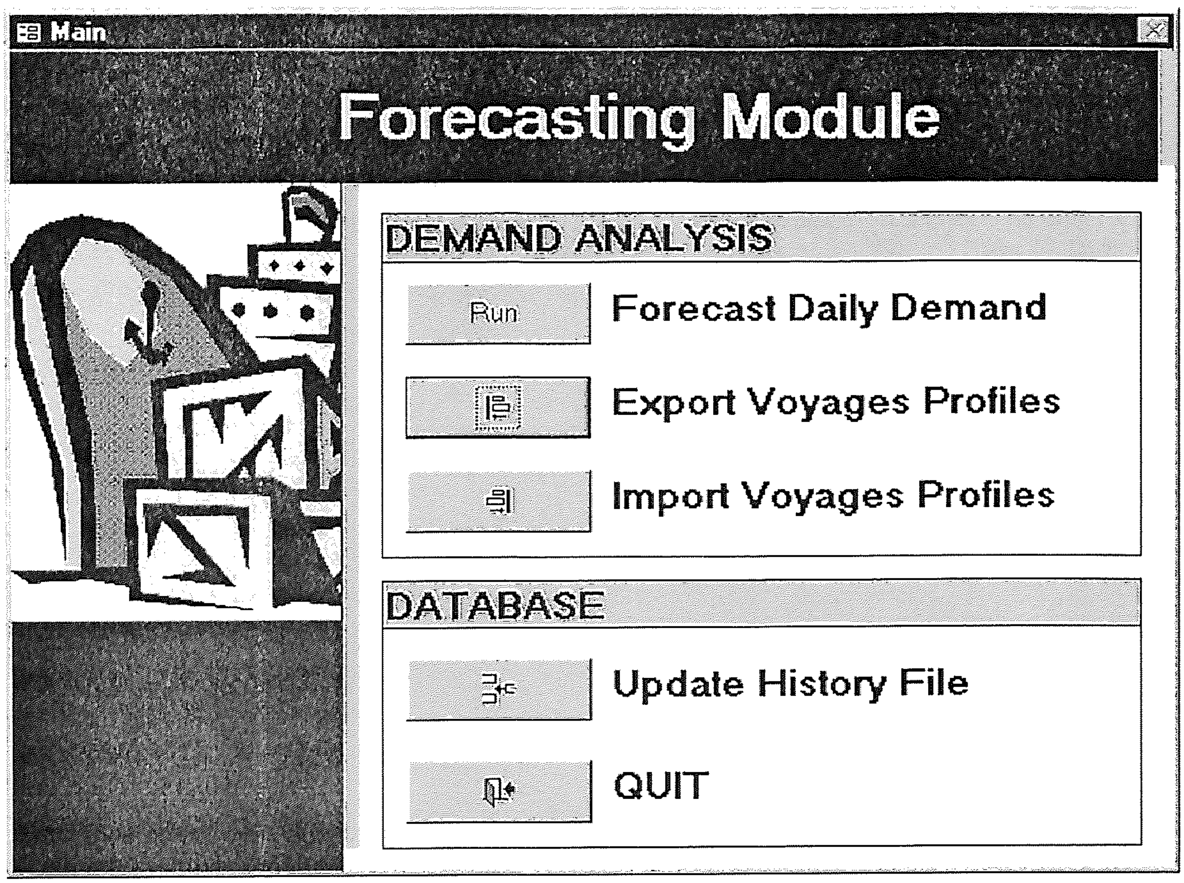


Figure 3.1 Main Form

3.2.1 Database Update Module

One of the most critical tasks to assure the success of the practical approach described herein is the continuous update of the current database. It is assumed that a monthly update would be sufficient for the current objectives. An easy to use procedure to update periodically the source voyages was implemented.

The fully automated process includes several routines and performs the task of importing and manipulating the input "History File". An overview of the import process and of the consequent manipulation of the data is given in Appendix A.

Figure 3.2 presents the form used to access the module.

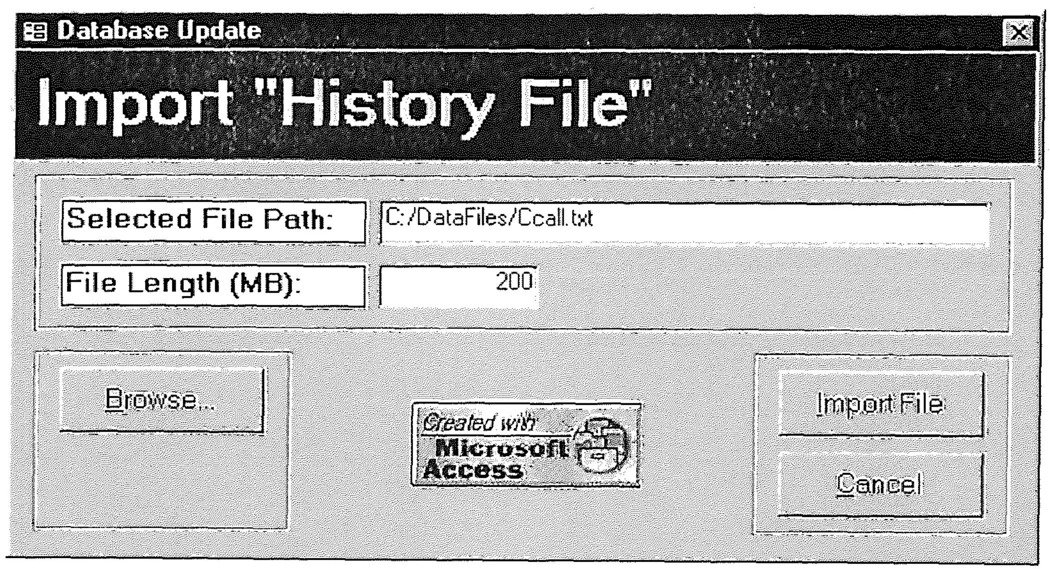


Figure 3.2 Import Form

3.2.2 Exports Module

Figure 3.3 shows the initial form in which the user selects the code of the vessel under consideration. The vessel code is a two-digit string, unique for each vessel. An updateable list provides information on the actual name of the ship and its ownership.

Consequently, the control is transferred to the next form (Figure 3.4), which provides analysis features for the selected vessel. Two options are currently available.

By selecting a particular voyage date, the user can retrieve from the database the demand pattern observed in any of the voyages available in the database. The results of the query are shown in Figure 3.5.

The general demand profile is constructed currently from all the available voyages for the particular vessel that occurred within the last seven months. For most vessels calling at the port, this period translates to a sample of 4 to 6 voyages. It is assumed that the current distribution is more likely to follow the pattern observed in the recent past. The weighted average of the daily demand is calculated to count for the deviations in shipment size. Allowing the user to select multiple voyages to be included in the model and excluding the rest will enhance this feature. The results are shown in Figure 3.6.

3.2.3 Imports Module

For the imports sector, the selection forms are identical to those used for the exports (Figures 3.3 & 3.4), whereas the information displayed by the controls refers to import container movements. Figure 3.7 provides the result of a sample query for a particular voyage. Figure 3.8 depicts the general demand profile for the selected vessel.

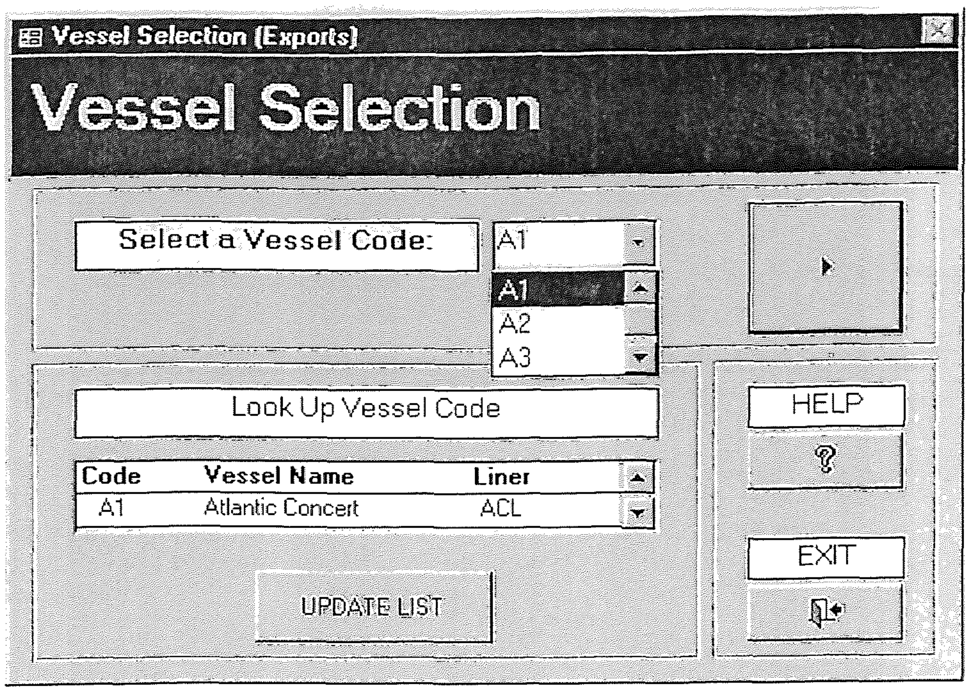


Figure 3.3 Vessel Selection Form

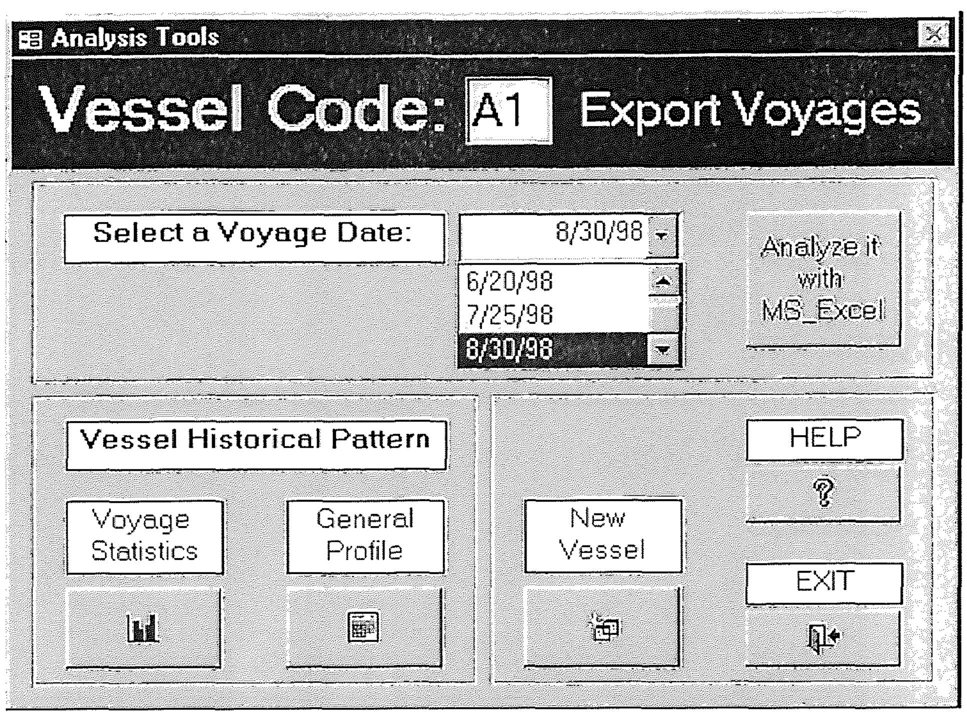


Figure 3.4 Analysis Tools Form

Statistics for Exports

Vessel Code: A1

Voyage Date: 8/30/98

By Truck	81
By Express Rail	9
SubTotal	90
Stuffed In Port	11
Transshipments	4
Grand Total	105

Date	Days Before	Total Exports	By Truck	Express Rail	Stuffed In Port	Transit In Port	Grand Totals	Percent (%)
8/21/98	9	1	1	0	0	0	1	0.95%
8/22/98	8	0	0	0	0	0	0	0.00%
8/23/98	7	0	0	0	0	0	0	0.00%
8/24/98	6	2	2	0	0	0	2	1.90%
8/25/98	5	9	9	0	0	1	10	9.52%
8/26/98	4	12	10	2	0	1	13	12.38%
8/27/98	3	25	25	0	0	0	25	23.81%
8/28/98	2	35	32	3	11	2	48	45.71%
8/29/98	1	0	0	0	0	0	0	0.00%

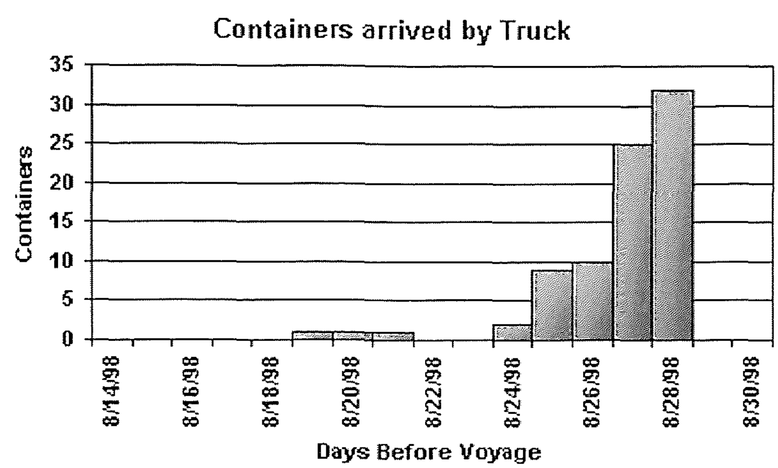


Figure 3.5 Statistics for One Voyage (Exports)

Statistics for Exports

Vessel Code: A1

Source Voyages

Num	VoyageDate	TruckTotal	StuffedTotal	TransitTotal	SubTotal (without Express Rail)	VoyageTotal (including Express Rail)
4	6/20/98	90	11	4	105	121
5	7/25/98	90	13	1	104	115

General Arrival Pattern Profiles

Days of Operation Before Voyage	Percent (%) ByTruck	Percent (%) Stuffed In Port	Percent (%) Transshipments	Percent (%) Totals
More	3.42	0.00	0.00	2.93
10	0.00	0.00	0.00	0.00
09	0.00	0.00	0.00	0.00
08	0.19	0.00	0.00	0.16
07	0.57	0.00	0.00	0.49
06	1.33	0.00	0.00	1.14
05	5.13	0.00	0.00	4.40
04	8.75	0.00	8.33	7.65
03	13.50	0.00	8.33	11.73
02	26.05	21.05	58.33	26.06
01	40.87	78.95	25.00	45.28
00	0.19	0.00	0.00	0.16

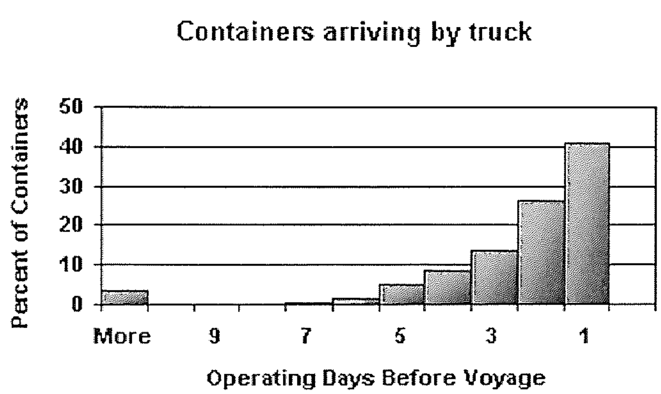


Figure 3.6 Vessel Daily Demand Profile (Exports)

Statistics for Imports

Vessel Code: A1

Voyage Date: 8/24/98

Imports	197
Striped In Port	24
SubTotal	221
Transshipments	0
GrandTotal	221

Date	DaysAfter	Imports	Striped	Transit	Totals	Percent
8/24/98	0	2	0	0	2	0.81%
8/25/98	1	26	0	0	26	10.57%
8/26/98	2	42	0	0	42	17.07%
8/27/98	3	34	1	0	35	14.23%
8/28/98	4	23	22	0	45	18.29%
8/29/98	5	0	0	0	0	0.00%
8/30/98	6	0	0	0	0	0.00%
8/31/98	7	42	0	0	42	17.07%
9/1/98	8	4	0	0	4	1.63%
9/2/98	9	7	0	0	7	2.85%

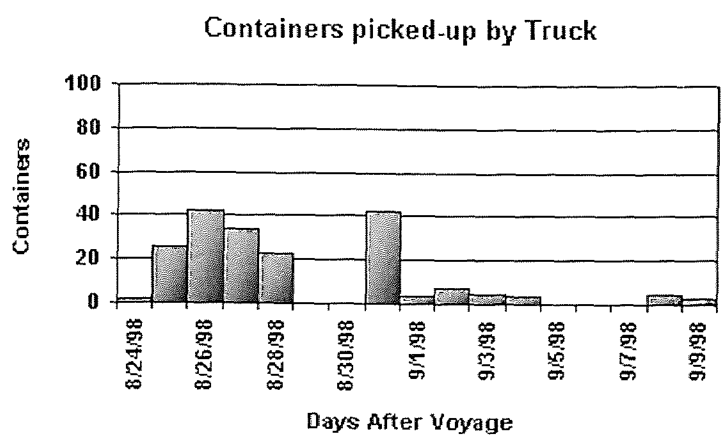


Figure 3.7 Statistics for One Voyage (Imports)

Statistics for Imports

Vessel Code: A1

Source Voyages

Num	VoyageDate	ImportsTotal	StripedTotal	TransitTotal	SubTotal (without Transit)	VoyageTotal (including Transit)
2	4/7/98	239	15	31	254	285
3	5/13/98	238	23	25	261	286

General Pick-Up Pattern Profiles

Days of Operation After Voyage	Percent (%) Imports	Percent (%) Striped In Port	Percent (%) Totals
00	1.70	0.00	1.57
01	22.54	0.00	20.90
02	20.00	32.43	20.90
03	14.06	9.91	13.76
04	14.42	42.34	16.45
05	12.65	0.00	11.73
06	5.72	0.00	5.31
07	3.46	0.00	3.21
08	1.63	0.90	1.57
09	1.91	6.31	2.23
10	0.71	0.00	0.66
More	1.20	8.11	1.70

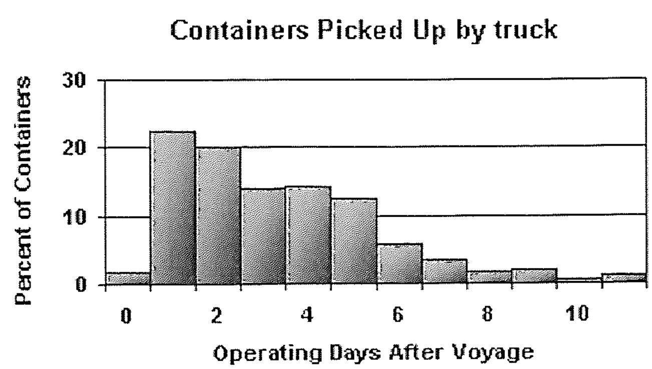


Figure 3.8 Vessel Daily Demand Profile (Imports)

3.2.4 Forecasting Module

The previously described modules fulfill the need to construct vessel specific demand patterns by replicating the historical information stored in the database. The next step involves the use of the vessel profiles to forecast the total daily demand. For a given sequence of scheduled voyages, overlaying in time the associated vessels profiles develops a projection of the total daily container arrivals. The process stipulates that the terminal operator has available a time-schedule of the upcoming vessel calls. Moreover, information on main attributes that describe forthcoming voyages is required as an input to the system. Table 3.2 provides a voyage attribute list along with a brief description.

Table 3.2 Voyage Main Attributes

Vessel Code	The two digit unique alphanumeric code. A look-up control is provided on the custom input form (Figure 3.9).
Expected Units	The total number of expected units. The number is fixed for the import section. For the export section a rough estimate is used.
Voyage Date	The "Voyage Date" as defined in the preceding. (Par. 3.1.2, p.22)
Voyage Type	Either an "Import" or an "Export" indication is required.

The user-input is stored in a temporary database table. Each voyage attribute is associated to a field in the table. Each entry (record) corresponds to a particular voyage. Figure 3.9 illustrates the customized input form. Controls for pre-viewing the current entries and editing are provided on the form. A table-view showing all the current entries is also available. Figure 3.10 displays a sample voyage sequence.

The forecast module execution is then accessed and the results are reported in a customized spreadsheet format. Figures 3.11 (a),(b),(c) present the complete forecast report generated by running the module for the input shown in Figure 3.10.

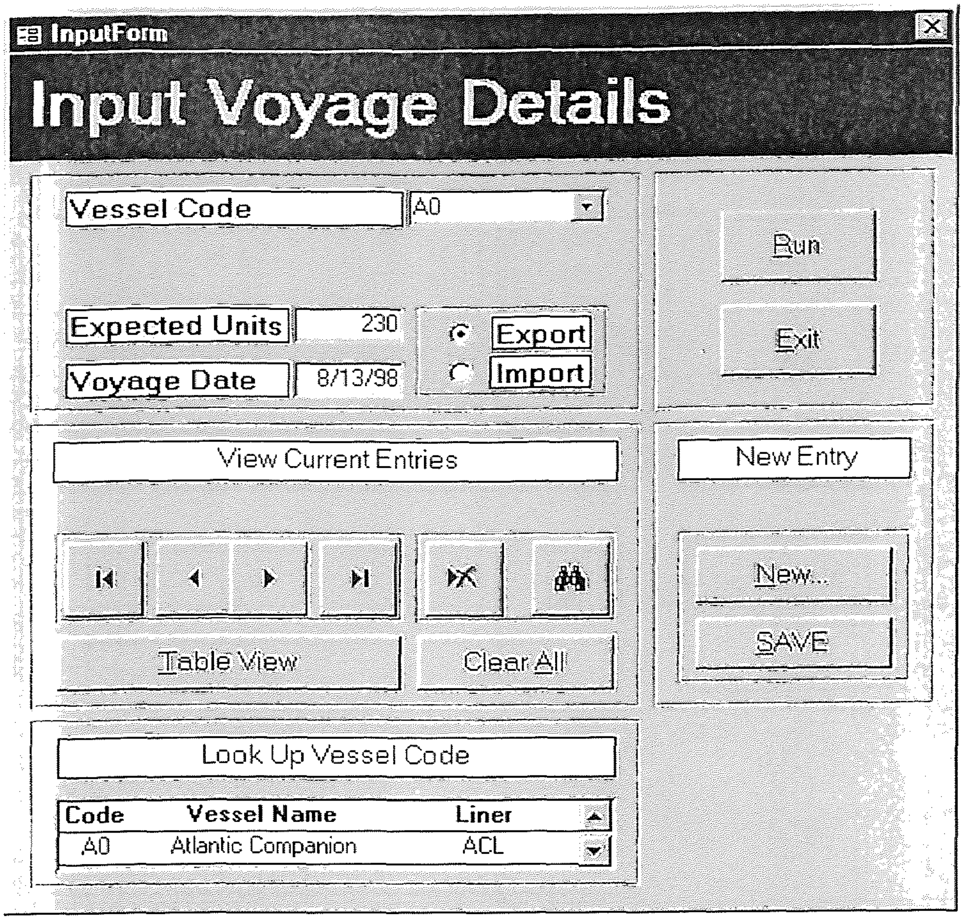
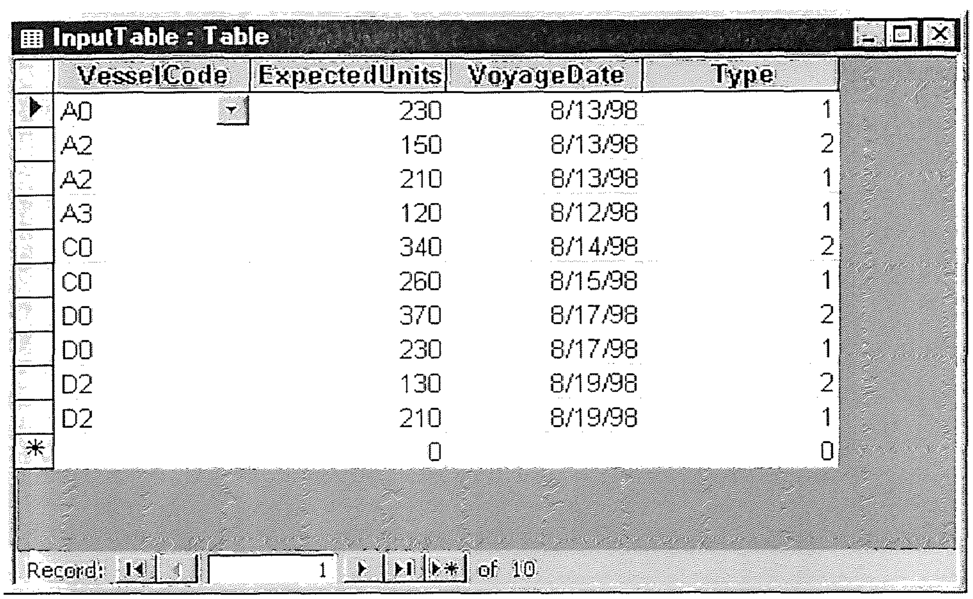


Figure 3.9 Input Form



InputTable : Table

VesselCode	ExpectedUnits	VoyageDate	Type
A0	230	8/13/98	1
A2	150	8/13/98	2
A2	210	8/13/98	1
A3	120	8/12/98	1
C0	340	8/14/98	2
C0	260	8/15/98	1
D0	370	8/17/98	2
D0	230	8/17/98	1
D2	130	8/19/98	2
D2	210	8/19/98	1
	0		0

Record: 1 of 10

Figure 3.10 Input Table

DEMAND DISTRIBUTION REPORT

	Vessel Code:	A3	A2	A2	A0	C0	C0	D0	D0	D2	D2	
	Voyage Date:	8/12/98	8/13/98	8/13/98	8/13/98	8/14/98	8/15/98	8/17/98	8/17/98	8/19/98	8/19/98	Total Daily Demand
	Expected Units:	120	210	150	230	340	260	230	370	210	130	
	Type:	Export	Export	Import	Export	Import	Export	Export	Import	Export	Import	
Date	WeekDay	Forecasted Daily Demand										
7/28/98	3	0										0
7/29/98	4	0	1		1							2
7/30/98	5	0	0		1		1					2
7/31/98	6	0	1		0		0	1				2
8/1/98	7											0
8/2/98	1											0
8/3/98	2	0	0		1		0	1				3
8/4/98	3	1	1		2		0	1		1		6
8/5/98	4	7	1		3		0	2		1		15
8/6/98	5	9	16		11		0	4		3		42
8/7/98	6	18	21		18		1	6		3		67
8/8/98	7											0
8/9/98	1											0
8/10/98	2	28	26		25		8	19		4		109
8/11/98	3	57	47		53		23	27		9		216
8/12/98	4	0	96		115		46	41		22		319
8/13/98	5		1	2	1		73	48		29		155
8/14/98	6			40		0	107	79		53		280
8/15/98	7											0
8/16/98	1											0
8/17/98	2			33		21		0	14	40		107
8/18/98	3			23		78			53	45		198

Figure 3.11(a) Demand Forecast Report - Part I

8/19/98	4			16		39			74	0	2	130
8/20/98	5			12		50			62		23	147
8/21/98	6			9		57			48		26	139
8/22/98	7											0
8/23/98	1											0
8/24/98	2			5		41			46		24	116
8/25/98	3			4		18			23		16	60
8/26/98	4			2		7			21		17	47
8/27/98	5			1		14			9		8	31
8/28/98	6			4		0			7		6	18
8/29/98	7											0
8/30/98	1											0
8/31/98	2					16			5		2	23
9/1/98	3								9		2	11
9/2/98	4										1	1
9/3/98	5										4	4
9/4/98	6											0
9/5/98	7											0
9/6/98	1											0
9/7/98	2											0
9/8/98	3											0
9/9/98	4											0
9/10/98	5											0
9/11/98	6											0
	Totals:	120	210	150	230	340	260	230	370	210	130	2250

Figure 3.11(a) (continued)

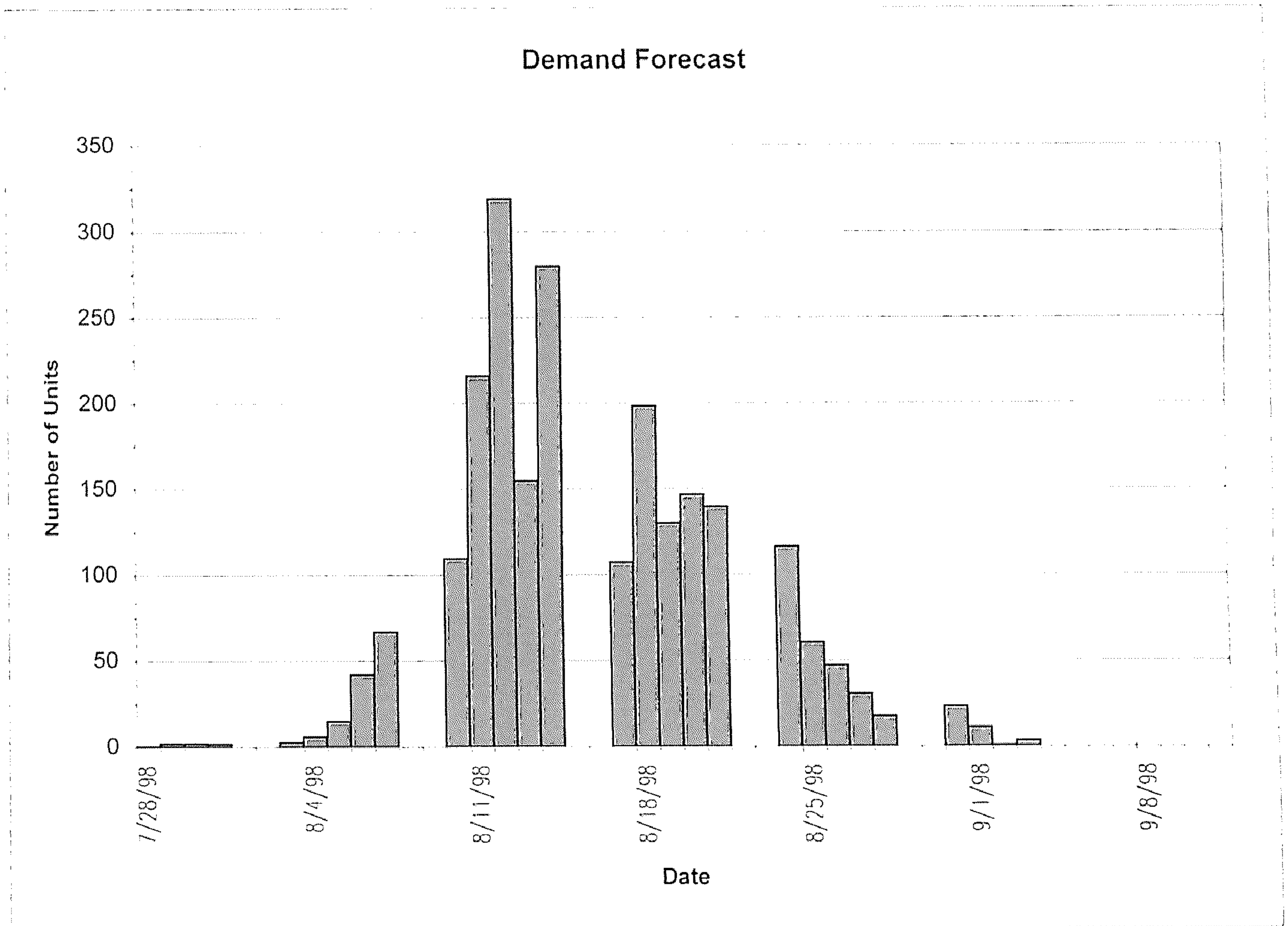


Figure 3.11(b) Demand Forecast Report - Part II

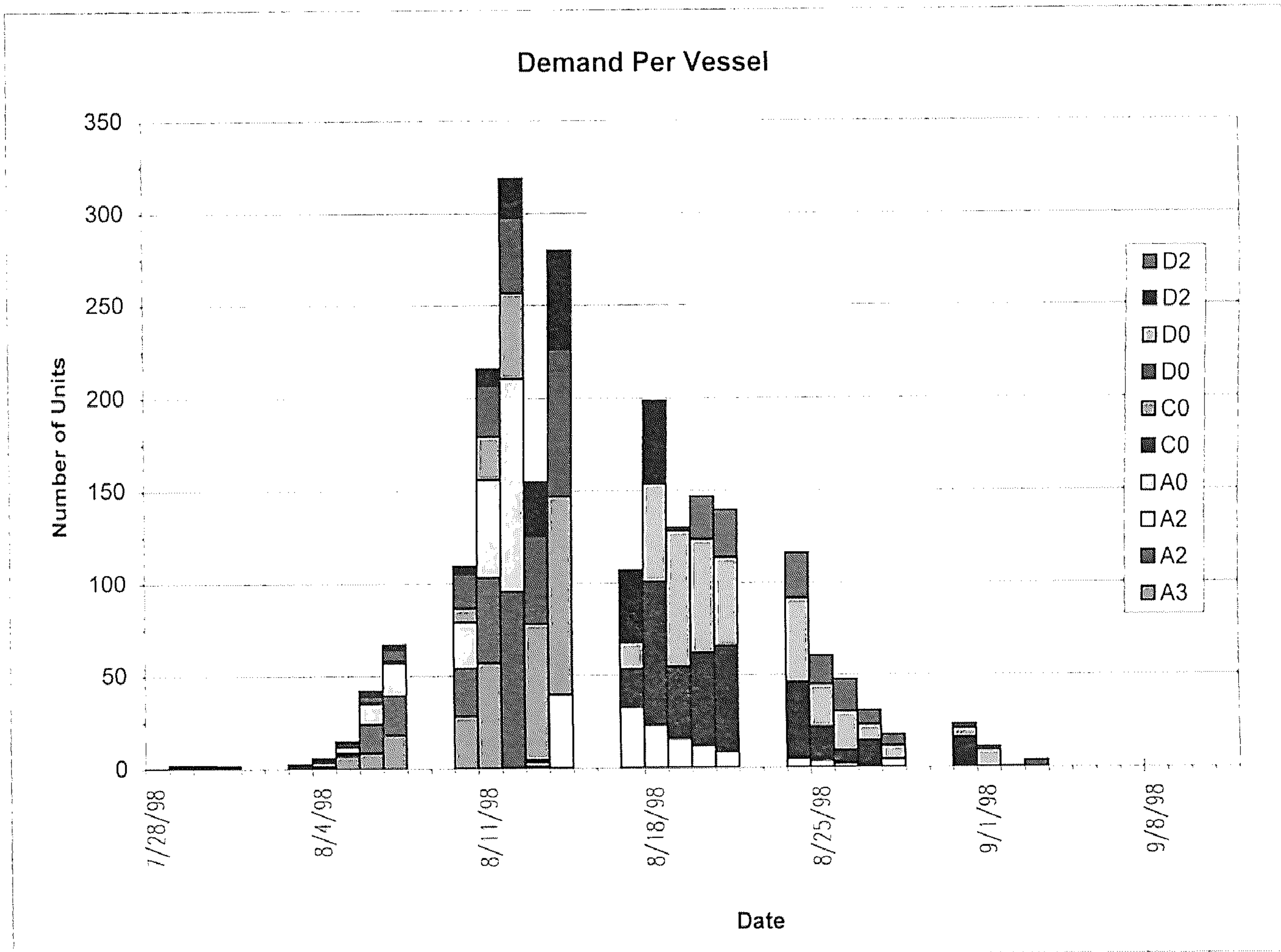


Figure 3.11(c) Demand Forecast Report - Part III

CHAPTER FOUR

MODEL EVALUATION

Chapter 3 focused on the description of the proposed methodology and the consequent implementation in the form of a custom management information system. In this chapter, an attempt to evaluate the credibility of the technique is addressed. Some important observations are also outlined.

4.1 Vessel Model Evaluation

The forecasting tool precision is primarily determined by the accuracy of the derived vessel demand profiles in replicating the actually observed demand. In this instance, the main difficulty was imposed by the fact that the model to be evaluated does not follow any theoretical distribution with prescribed analytical formulation. In contrast, it is the model being directly developed by actual data. Therefore, the employment of a formalized statistical method to test the goodness of fit is questionable. Descriptive statistics and observation should be considered as better candidates for that process. Additionally, it should be noted that since the analysis was grounded on the conceptual approach of the on per vessel analysis, it is impractical to generalize any findings. In the bottom line the problem was addressed at a certain extend through a formalized comparison of the actual demand for recent voyages with the scenario constructed from the historical information. A few interesting conclusions were drawn at this point.

4.1.1 Export Voyages

The evaluation process is fully integrated within the voyage information retrieval tool as described in the previous chapter. Once a voyage date is selected and by clicking the corresponding button the data associated with the particular voyage are copied from the database to a new spreadsheet. Next, the distribution model is developed to allow for comparison.

Figure 4.1 illustrates the report created for a sample voyage in tabular form. Figures 4.2 and 4.3 present the information in graphical format as part of the custom report. Additional sample reports have been included in Appendix C.

The upper part of Figure 4.1 includes the actual distribution patterns that were observed for the particular voyage, whereas the lower part includes the model distributions developed from the information on past voyages.

To investigate, the relationship between the two distributions, the values of two basic statistical indexes, namely that of the correlation coefficient and the standard error, were derived.

The correlation coefficient ρ_{xy} is defined as:

$$\rho_{xy} = \frac{Cov(x,y)}{\sigma_x \cdot \sigma_y}$$

where,

$$Cov(x,y) = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu_x)\cdot(y_i - \mu_y)$$

and,

x_i = observed value for demand i days before voyage
y_i = estimated value for demand i days before voyage
n = sample size
μ_x = observed values mean
μ_y = estimated values mean
σ_x = observed values standard deviation
σ_y = estimated values standard deviation

The standard error S_{yx} is defined as:

$$S_{yx} = \sqrt{\left[\left[\frac{1}{n(n-2)}\right]\cdot\left[n\sum y^2 - (\sum y)^2 - \frac{\left[n\sum xy - (\sum x)(\sum y)\right]^2}{n\sum x^2 - (\sum x)^2}\right]\right]}$$

A series of runs were performed and the results are summarized in Table 4.1. Twenty-four recent voyages of different vessels were examined. It is notable that for most voyages the correlation coefficient is relatively high ($\rho > 0.80$) indicating a sufficient adjustment of the derived model to the actually observed values. The standard error is considered acceptable in practice.

Analyzing the results of the evaluation tool also drew two important indirect conclusions. Foremost, there is a significant concentration of container arrivals close to the scheduled voyage date. It is verified that for most voyages more than 60% of the arrivals are scheduled within a period up to 3 days before vessel departure. In addition, the graphical outputs indicate that the demand distributions for vessels owned by the same ocean carrier follow similar patterns. The reason for that requires further study, which is not presented herein.

Table 4.1 Export Voyages Analysis

EXPORT VOYAGES			Correlation Coefficients		Standard Error		Squared Errors Sum	
Vessel Name	**Vessel Code**	**Date**	Truck	Total	Truck	Total	Truck	Total
Rio Grande	Q5	8/20/98	.8457	.8457	5.49	5.49	43.46	43.46
Copacabana	I7	8/23/98	.8274	.8174	5.90	6.06	145.24	150.45
Fei He	K4	8/24/98	.8691	.8623	5.68	5.96	37.69	40.30
MSC Santiago	G4	8/25/98	.9052	.9032	5.07	5.13	29.08	29.21
Infanta	E3	8/26/98	.8064	.8064	7.59	7.59	48.08	48.08
Argonaut	F1	8/27/98	.8791	.7448	2.65	5.60	22.66	35.05
Tamamonta	Q8	8/27/98	.9259	.9259	3.67	3.67	21.76	21.76
Atlantic Concert	A1	8/30/98	.9815	.9929	2.68	1.81	9.84	7.94
Empress Dragon	K7	8/30/98	.7702	.8235	5.19	4.62	29.64	26.24
MSC Bogota	G2	9/1/98	.8083	.8115	6.11	6.06	67.46	67.49
POL America	H2	9/3/98	.8742	.8705	5.25	5.26	33.45	34.35
Oleander	C0	9/4/98	.9862	.9850	2.51	2.48	4.33	3.36
MSC Jessica	Q6	9/4/98	.9205	.9205	4.52	4.52	24.87	24.87
Atlantic Compass	A2	9/5/98	.9887	.9801	2.46	3.55	22.41	20.79
Empress Heaven	K8	9/12/98	.8575	.8332	4.45	4.63	53.09	68.15
Endurance	F5	9/14/98	.3780	.5603	6.24	7.91	46.00	60.90
MSC New York	H3	9/16/98	.9285	.9291	4.19	4.17	21.10	20.98
Atl. Companion	A0	9/19/98	.9948	.9982	1.65	1.10	12.69	9.12
Columbia Florida	C2	9/19/98	.8166	.8005	6.37	6.61	61.35	63.71
Trade Apollo	D0	9/20/98	.9628	.9618	3.29	3.33	13.16	13.25
MSC Brazil	E6	9/22/98	.9070	.9070	3.99	3.99	31.36	31.36
MSC Insa	H6	9/23/98	.9568	.9551	3.66	3.75	19.20	19.61
Amer. Resolute	F7	9/25/98	.5928	.6829	4.28	4.26	25.51	23.76
James	D2	9/27/98	.9553	.9500	3.23	3.32	11.55	11.60

MODEL EVALUATION: Exports

Vessel Code:	A0	Voyage Date:	9/19/98

Actual Voyage Demand Distribution (Percentages %)

Days Before	Truck	Stuffed in Port	Transshipments	Totals
More	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
8	1.49	0.00	0.00	1.11
7	0.00	0.00	0.00	0.00
6	1.49	0.00	0.00	1.11
5	2.99	0.00	0.00	2.22
4	5.97	0.00	0.00	4.44
3	10.45	0.00	100.00	10.00
2	26.87	0.00	0.00	20.00
1	50.75	100.00	0.00	61.11
0	0.00	0.00	0.00	0.00

Correlation Coefficients CORREL(Actual, Projected)

	0.9948			0.9982

Model Projected Demand Distribution (Percentages %)

Days Before	pTruck	pStuffed in Port	pTransshipment	pTotals
More	0.64	0.00	0.00	0.51
10	0.43	0.00	0.00	0.34
9	0.00	0.00	0.00	0.00
8	0.21	0.00	0.00	0.17
7	1.07	0.00	0.00	0.85
6	1.28	0.97	0.00	1.18
5	4.93	0.00	0.00	3.89
4	7.92	0.00	0.00	6.26
3	10.92	0.00	19.05	9.31
2	22.27	0.00	0.00	17.60
1	49.68	99.03	80.95	59.39
0	0.64	0.00	0.00	0.51

Standard Error STEYX(Actual, Projected)

Stnd Error	1.65			1.10
Sqrd Error (Sum)	12.69			9.12

Figure 4.1 Model Evaluation Sample Report (Exports - Part I)

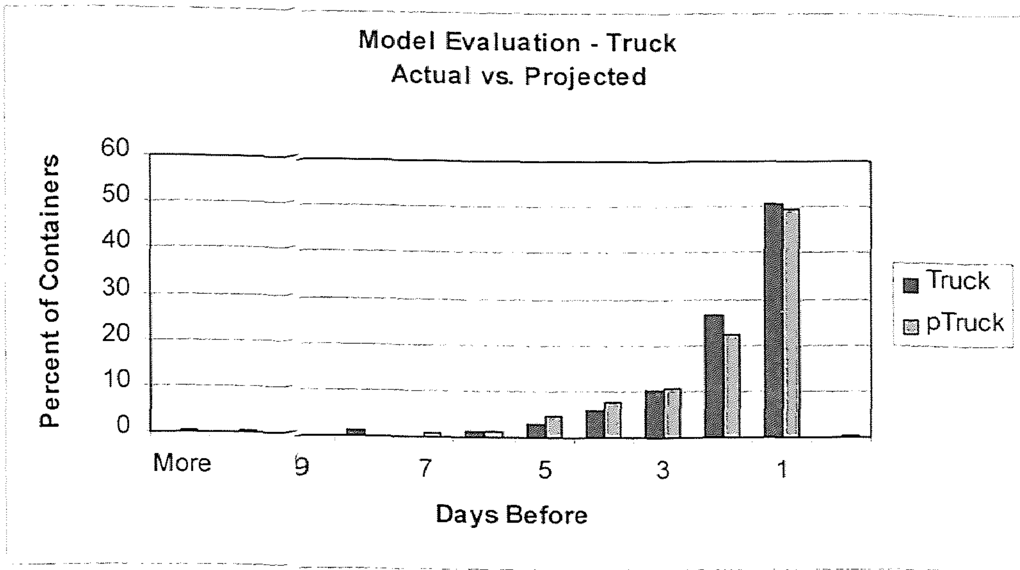


Figure 4.2 Model Evaluation Sample Report (Exports – Part II)

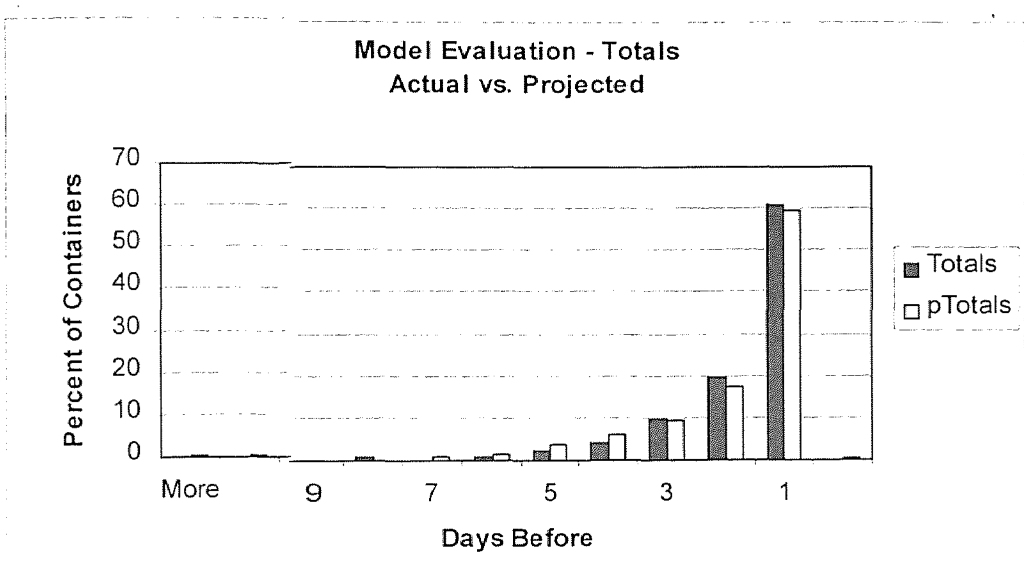


Figure 4.3 Model Evaluation Sample Report (Exports – Part III)

4.1.2 Import Voyages

For the import section the analysis included 29 (twenty-nine) recent voyages. The analysis results are summarized in Table 4.2. The derived statistical indexes justify the model applicability at the operational level. Figures 4.4, 4.5 and, 4.6 illustrate a sample report for this category. In general, the pick-up process for import containers is distributed more evenly over the period after vessel arrival.

Table 4.2 Import Voyages Analysis

IMPORT VOYAGES			Correlation Coefficients		Standard Error		Squared Errors Sum	
Vessel Name	**Vessel Code**	**Date**	Truck	Total	Truck	Total	Truck	Total
MSC Stefania	H7	8/5/98	.8949	.8949	3.25	3.25	14.33	14.33
Columbia Florida	C2	8/7/98	.7674	.7674	8.34	8.34	59.20	59.20
Enterprise	F6	8/8/98	.8904	.8901	2.85	2.85	29.74	29.82
N/A	D5	8/10/98	.8725	.8728	3.21	3.20	12.90	12.75
Mbashi	E4	8/12/98	.9715	.9715	2.04	2.04	13.68	13.68
Amer. Resolute	F7	8/16/98	.8747	.8747	3.94	3.94	15.21	15.21
Atlantic Cartier	A4	8/17/98	.9263	.9524	3.16	2.54	15.30	12.29
MSC Nicole	G3	8/18/98	.9120	.9120	3.50	3.50	14.55	14.55
MSC Mirella	E1	8/19/98	.9307	.9307	2.19	2.19	15.67	15.67
N/A	U1	8/21/98	.9086	.9086	3.19	3.19	13.46	13.46
Copacabana	I7	8/22/98	.8678	.8673	5.05	5.06	25.79	25.79
Atlantic Concert	A1	8/24/98	.8098	.8330	5.01	4.73	35.53	22.03
James	D2	8/24/98	.9819	.9819	1.62	1.62	4.26	4.26
Infanta	E3	8/26/98	.9528	.9521	2.89	2.91	15.55	15.72
Argonaut	F1	8/27/98	.8489	.8489	3.72	3.72	25.18	25.18
POL America	H2	8/30/98	.8805	.8805	3.18	3.18	37.02	37.02
Atlantic Compass	A2	9/1/98	.8783	.8315	4.91	5.66	34.54	36.83
MSC Bogota	G2	9/1/98	.5869	.5869	7.67	7.67	70.16	70.16
Atlantic Conveyor	A3	9/8/98	.9130	.9313	3.30	3.14	12.85	11.15
Nolizwe	E0	9/9/98	.9270	.9270	2.49	2.49	39.79	39.79
Empress Heaven	K8	9/11/98	.8057	.8057	3.55	3.55	26.46	26.46
MSC New York	H3	9/12/98	.9461	.9460	2.56	2.56	9.21	9.23
Endurance	F5	9/13/98	.7872	.7873	4.05	4.05	26.67	26.51
Atl. Companion	A0	9/14/98	.9225	.9340	3.09	2.89	15.53	15.29
Trade Apollo	D0	9/14/98	.9465	.9464	2.25	2.25	22.87	22.91
Nomzi	E7	9/16/98	.8114	.8114	4.14	4.14	34.77	34.77
MSC Insa	H6	9/18/98	.9708	.9688	2.33	2.33	12.88	13.14
Jing Po He	K3	9/18/98	.8109	.8109	5.01	5.01	36.08	36.08
P&Q Chile	P1	9/21/98	.9655	.9655	2.89	2.89	30.18	30.18

MODEL EVALUATION: Imports

Vessel Code: A0 **Voyage Date:** 9/14/98

Actual Voyage Demand Distribution

Days After	Imports	Striped in Port	Totals
0	0.00	0.00	0.00
1	13.97	0.00	13.56
2	17.03	0.00	16.53
3	18.78	0.00	18.22
4	17.90	85.71	19.92
5	14.85	0.00	14.41
6	8.73	0.00	8.47
7	2.18	0.00	2.12
8	2.62	0.00	2.54
9	0.44	14.29	0.85
10	3.06	0.00	2.97
More	0.44	0.00	0.42

Correlation Coefficients CORREL(Actual, Projected)

0.9225 0.9340

Model Projected Demand Distribution

Days After	pImports	pStriped in Port	pTotals
0	3.36	0.00	3.12
1	19.80	0.93	18.45
2	19.66	12.04	19.11
3	18.94	31.48	19.84
4	13.80	53.70	16.66
5	11.37	0.00	10.55
6	5.00	0.00	4.64
7	3.50	0.00	3.25
8	1.29	0.93	1.26
9	0.57	0.00	0.53
10	1.29	0.00	1.19
More	1.43	0.93	1.39

Standard Error STEYX(Actual, Projected)

Stnd Error	3.09	2.89
Sqrd Error (Sum)	15.53	15.29

Figure 4.4 Model Evaluation Sample Report (Imports – Part I)

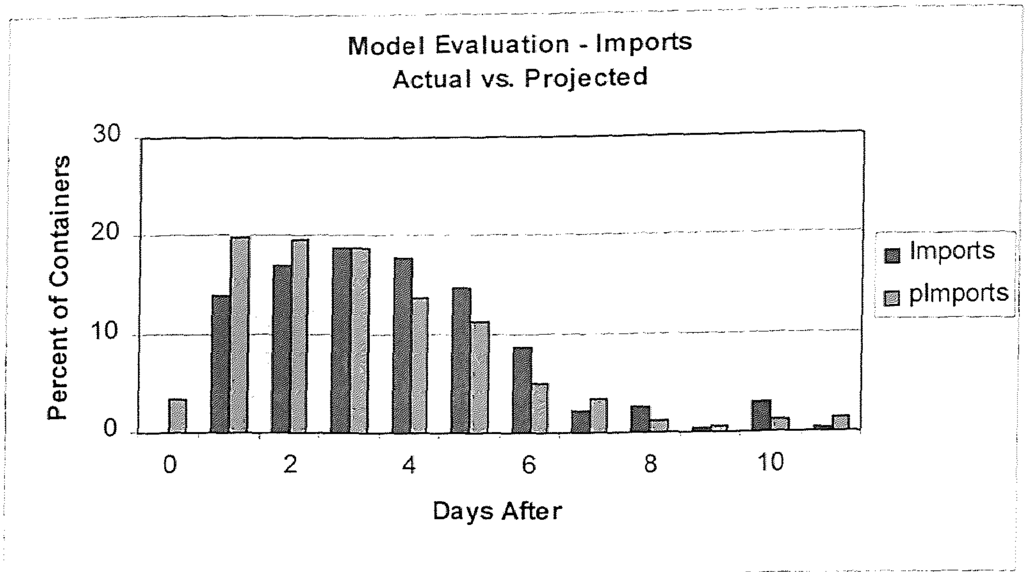


Figure 4.5 Model Evaluation Sample Report (Imports – Part II)

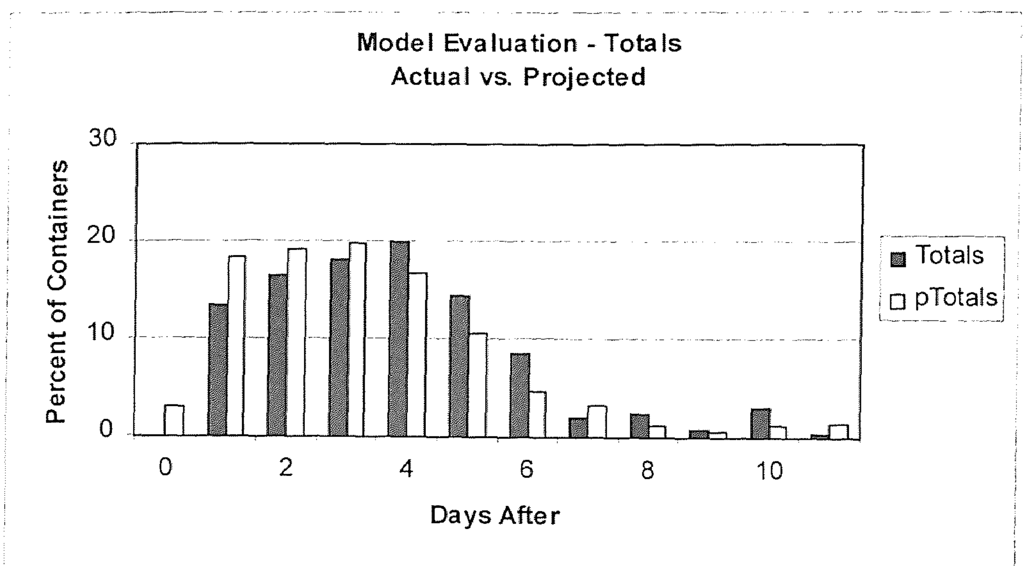


Figure 4.6 Model Evaluation Sample Report (Imports – Part III)

4.2 General Schedule Forecast Evaluation

In addition, to the implemented evaluation modules that dealt with single voyages of particular vessels, an example demonstrating the general applicability of the forecasting technique in the representation of an actual sequence of vessels calling at the terminal is presented in this section.

The scenario of the exercise included all the voyages for a specified time-period, namely from 8/22/98 to 9/5/98. The main attributes for the voyages are shown in Table 4.3 sorted by date.

Table 4.3 Voyage Sequence (8/22/98 – 9/5/98)

Vessel Name	Vessel Code	Date	Section[1]	Expected # of Units[2]	Actual # of Units
Copacabana	I7	8/22/98	I	110	108
Copacabana	I7	8/23/98	E	130	130
Atlantic Concert	A1	8/24/98	I	200	197
James	D2	8/24/98	I	440	440
MSC Santiago	G4	8/25/98	E	80	80
Infanta	E3	8/26/98	E	25	22
Infanta	E3	8/26/98	I	200	201
Tamamonta	Q8	8/27/98	E	55	55
Argonaut	F1	8/27/98	E	80	77
Argonaut	F1	8/27/98	I	190	190
POL America	H2	8/30/98	I	500	494
Empress Dragon	K7	8/30/98	E	90	90
Atlantic Concert	A1	8/30/98	E	80	81
Atlantic Compass	A2	9/1/98	I	230	232
MSC Bogota	G2	9/1/98	E	80	78
MSC Bogota	G2	9/1/98	I	110	113
POL America	H2	9/3/98	E	140	141
Oleander	C0	9/4/98	E	140	142
MSC Jessica	Q6	9/4/98	E	60	60
Atlantic Compass	A2	9/5/98	E	50	54

1. I denotes Import and E denotes Export
2. User Input

The table includes eight inbound (imports) voyages and twelve outbound (exports) voyages. For seven vessels both the inbound and the outbound trips were included in the period under examination. The "Expected # of Units" in the fifth column refers to the total demand forecast for each voyage. It should be noted that for the import section the total demand is in general fixed, since the ocean carriers are required to provide detailed information to the port authorities before the vessel arrival. For the export section, a reasonable approximation can be used, based on past voyages historic data, general time-related trends and, current information.

The information on the actual voyages demand distribution was retrieved by a series of queries as described in paragraphs 3.2.2 and 3.2.3 of the previous chapter. The daily total demand is calculated by overlaying the voyage specific distributions in a general time-activity sheet. A report on the actually observed demand is shown in Figure 4.7.

Likewise, for the forecasted demand a similar sheet is created and the report is shown in Figure 4.8. For this instance the module described in paragraph 3.2.4 was used.

A rough analysis of the relationship between the observed and the estimated values for the examined case gave a correlation coefficient of 0.9723 and a standard error of 23.32. The situation is depicted graphically in Figure 4.9.

It is emphasized that all the results should be seen within the context of a practical tool. The forecast for the examined situation is literally done, based on information as of 8/5/98. It is conceived that in an actual operation, the daily application of the tool will be required to incorporate the most updated information, including possible vessel schedule changes.

DEMAND DISTRIBUTION REPORT: Actual

Vessel Code:		I7	I7	A1	D2	G4	E3	E3	Q8	F1	F1	H2	K7	A1	A2	G2	G2	H2	C0	Q6	A2	Total Daily Demand Actual
Voyage Date:		8/22/98	8/23/98	8/24/98	8/24/98	8/25/98	8/26/98	8/26/98	8/27/98	8/27/98	8/27/98	8/30/98	8/30/98	8/30/98	9/1/98	9/1/98	9/1/98	9/3/98	9/4/98	9/4/98	9/5/98	
Expected Units:		110	130	200	440	80	25	200	55	80	190	500	90	80	230	80	110	140	140	60	50	
Type:		Import	Export	Import	Import	Export	Export	Import	Export	Export	Import	Import	Export	Export	Import	Export	Import	Export	Export	Export	Export	
Date	WeekDay	Actual Daily Demand Per Vessel																				
8/5/98	4																					0
8/6/98	5																					0
8/7/98	6		1																			1
8/8/98	7		0																			0
8/9/98	1		0			0																0
8/10/98	2		0			0	0															0
8/11/98	3		0			0	0		0	2												2
8/12/98	4		0			0	1		0	1												2
8/13/98	5		2			0	0		0	2												4
8/14/98	6		11			0	0		0	1			5	0								17
8/15/98	7		0			0	0		0	0			0	0								0
8/16/98	1		0			0	0		0	0			0	0		0						0
8/17/98	2		14			3	0		0	4			0	0		0						21
8/18/98	3		10			13	0		1	3			0	0		0		0				27
8/19/98	4		26			11	3		3	6			3	1		1		0	0	0		54
8/20/98	5		33			15	0		8	9			5	1		0		2	0	0	0	73
8/21/98	6		33			29	2		7	14			3	1		1		3	0	0	0	93
8/22/98	7	0	0			0	0		0	0			0	0		0		0	0	0	0	0
8/23/98	1	0	0			0	0		0	0			0	0		0		0	0	0	0	0
8/24/98	2	22		2	2	9	3		8	9			13	2		10		2	0	2	0	84
8/25/98	3	35		26	76	0	9		15	12			10	9		5		2	0	1	0	200
8/26/98	4	6		42	89		4	6	11	11			15	10		6		10	0	3	0	213
8/27/98	5	14		34	86			63	2	3	6		19	25		10		13	0	5	1	281
8/28/98	6	13		23	71			38			29		17	32		23		19	0	4	0	269
8/29/98	7	0		0	0			0			0		0	0		0		0	0	0	0	0
8/30/98	1	0		0	0			0			0	0	0	0		0		0	0	0	0	0
8/31/98	2	5		42	57			26			18	57				19		27	4	7	2	264
9/1/98	3	4		4	19			21			23	87			8	3	0	49	17	12	4	251
9/2/98	4	1		7	18			10			34	85			66		23	14	19	23	5	305
9/3/98	5	2		5	8			14			39	73			58		33	0	36	2	14	284
9/4/98	6	2		4	6			11			14	54			35		13		66	1	28	234
9/5/98	7	0		0	0			0			0	0			0		0				0	0
9/6/98	1	0		0	0			0			0	0			0		0					0
9/7/98	2	4		0	0			0			0	0			0		0					4
9/8/98	3			5	2			4			7	56			20		6					100
9/9/98	4			3	6			3			5	26			24		17					84
9/10/98	5							3			9	14			1		3					30
9/11/98	6							2			0	13			2		6					23
9/12/98	7										6	0			0		0					6
9/13/98	1											0			0		0					0
9/14/98	2											13			3		5					21
9/15/98	3											16			3		2					21
9/16/98	4														4		0					4
9/17/98	5														8		5					13
9/18/98	6																					0
9/19/98	7																					0
9/20/98	1																					0
9/21/98	2																					0
	Totals:	108	130	197	440	80	22	201	55	77	190	494	90	81	232	78	113	141	142	60	54	2985

Figure 4.7 Total Demand Report: Actual

DEMAND DISTRIBUTION REPORT: Forecast

	Vessel Code:	I7	I7	A1	D2	G4	E3	E3	Q8	F1	F1	H2	K7	A1	A2	G2	G2	H2	C0	Q6	A2	Total Daily Demand Projected
	Voyage Date:	8/22/98	8/23/98	8/24/98	8/24/98	8/25/98	8/26/98	8/26/98	8/27/98	8/27/98	8/27/98	8/30/98	8/30/98	8/30/98	9/1/98	9/1/98	9/1/98	9/3/98	9/4/98	9/4/98	9/5/98	
	Expected Units:	110	130	200	440	80	25	200	55	80	190	500	90	80	230	80	110	140	140	60	50	
	Type:	Import	Export	Import	Import	Export	Export	Import	Export	Export	Import	Import	Export	Export	Import	Export	Import	Export	Export	Export	Export	
Date	WeekDay	Forecasted Daily Demand Per Vessel																				
8/5/98	4																					0
8/6/98	5		3																			3
8/7/98	6		0																			0
8/8/98	7																					0
8/9/98	1																					0
8/10/98	2		1			2																3
8/11/98	3		2			0	0															2
8/12/98	4		6			1	0		1	4												12
8/13/98	5		3			1	0		1	0			3	3								12
8/14/98	6		16			3	0		0	1			1	0								21
8/15/98	7																					0
8/16/98	1																					0
8/17/98	2		10			5	1		2	1			1	0		1						20
8/18/98	3		16			10	1		3	2			2	0		2						37
8/19/98	4		26			13	2		3	5			7	0		2		2				60
8/20/98	5		45			14	2		7	8			7	1		2		1	0	1	0	89
8/21/98	6		2			18	3		6	12			11	4		3		1	0	0	0	61
8/22/98	7																					0
8/23/98	1																					0
8/24/98	2	1		3	6	12	6		7	14			14	7		8		2	0	1	0	81
8/25/98	3	20		45	78	0	7		10	16			18	11		7		2	0	1	0	216
8/26/98	4	26		40	87		3	13	12	15			14	21		13		8	0	2	0	254
8/27/98	5	15		28	83			60	1	2	5		12	33		10		15	0	4	0	269
8/28/98	6	16		29	53			34			32		0	0		15		17	1	4	4	205
8/29/98	7																					0
8/30/98	1																					0
8/31/98	2	15		25	59			26			32	0				16		25	4	7	5	213
9/1/98	3	5		11	26			16			31	76			4	1	4	40	12	12	6	243
9/2/98	4	3		7	20			12			28	113			61		18	28	25	18	11	343
9/3/98	5	2		3	8			10			31	87			50		24	0	39	7	23	285
9/4/98	6	1		4	6			8			10	70			36		16		58	2	0	211
9/5/98	7																					0
9/6/98	1																					0
9/7/98	2	1		1	2			6			4	61			24		10					109
9/8/98	3	6		2	12			3			6	15			18		17					80
9/9/98	4							2			4	24			13		10					53
9/10/98	5							11			3	14			7		2					38
9/11/98	6										4	9			6		3					21
9/12/98	7																					0
9/13/98	1																					0
9/14/98	2											9			3		3					15
9/15/98	3											22			1		1					24
9/16/98	4														7		2					9
9/17/98	5																					0
9/18/98	6																					0
9/19/98	7																					0
9/20/98	1																					0
9/21/98	2																					0
	Totals:	110	130	200	440	80	25	200	55	80	190	500	90	80	230	80	110	140	140	60	50	2990

Figure 4.8 Total Demand Report: Forecast

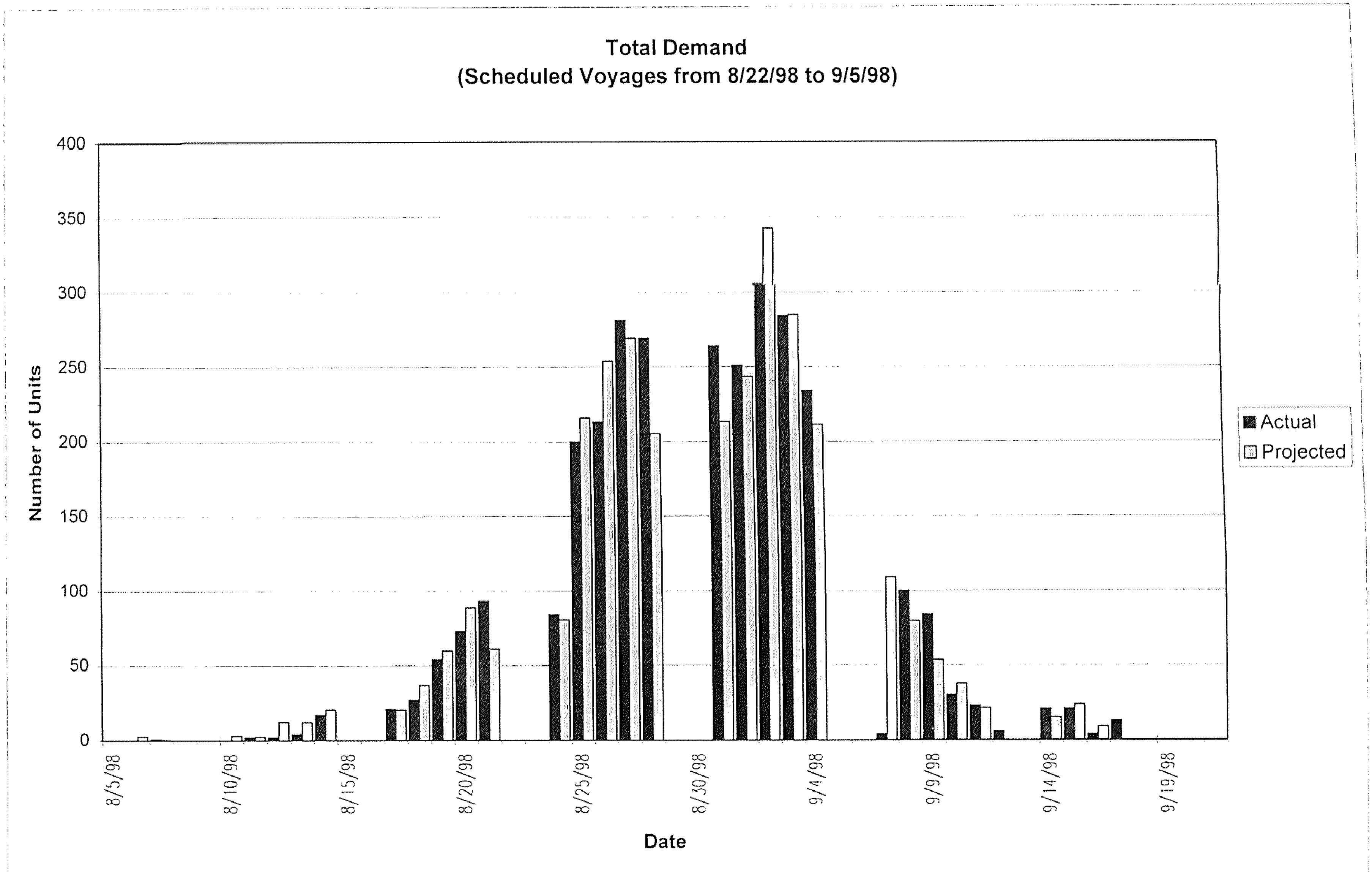


Figure 4.9 Total Demand Graph: Forecast vs. Actual

CHAPTER FIVE

CONCLUSIONS AND FURTHER RESEARCH

A practical approach for forecasting the daily demand at a container terminal was presented. The key element of the proposed method is the distinction of the scheduled containership voyage as the essential basis for the forecast. The demand forecasting procedure is focusing on the distribution of the total estimated demand associated to a particular voyage over the time period before and after the scheduled voyage date. Critical requirements are discussed and potential implications are explained. A set of forecasting models asserting various levels of available information was introduced and the particular difficulties on the model implementation were explored.

Finally, a procedure on the development of the necessary distribution patterns was fully implemented through the manipulation of information captured at an existing terminal. The data originated directly from the current logistics system in use at the terminal and were integrated in a user-friendly database to assist in the operating strategy decision process. The system is capable of displaying information in both tabular and graphical formats. The information on daily demand is grouped by mode.

The evaluation of the current solution revealed a satisfactory fit of the forecasting model projections to the actually observed patterns. As stated previously, the evaluation process serves solely the practical objectives of the project. The current approach is unfavorable to the use of applied statistical tests, due to the lack of a solid theoretical background.

In general the current solution should be seen as a decision support system, which is designed to assist the terminal activity planning in conjunction with the coherent experience of the operating team.

An extension to the current study will require the further enhancement of the forecasting models. The inclusion of the inventory control as described in Model II+ shares a lot of potential in improving the forecast. Key recommendations include the formalization of the knowledge related to the scheduled voyage dates. The availability of additional information acquired by the port customers and broker companies should be investigated.

APPENDIX A

DATA ACQUISITION & COMPILATION

This section highlights the process of obtaining the required distributions of export and import containers arrivals/pick-ups from the available data. The description of the system elements refers to the actual terminology and encoding scheme used in the original source of information. The methodology is compacted in a rigorously defined list of required tasks. The current account serves as an overview of the detailed technical report that follows in Appendix B.

STEP 1. Sort records by container number and activity date (*contnum* & *cont-history-date* and *cont-history-time*).

STEP 2. Split container movements into Imports and Exports. The different types of movements are shown in the following lists for the export and the import section respectively.

Hereinafter, the steps are separated for exports and imports respectively.

For Exports (Load)

Categories of Exports Movements:

1. **In By Truck** (*Status* = X3) - **Out By Ship** (*Status* = X2)
2. **In By Express Rail** (*Status* = X3 , *Carrier* = EXPRL) - **Out By Ship** (*Status* = X2)
3. **Stuffed In Port** (*Status* = X6) - **Out By Ship** (*Status* = X2)
4. **Transshipment In** (*Status* = T1) - **Transshipment Out** (*Status* = T2)

STEP 3. For an X3 (or X6 or T1) record keep: Date & Time of arrival + Vessel ID + Carrier.

STEP 4. For a related X2 (or T2) record keep: Date & Time of loading and Voyage#. The relation between X2 (or T2) and X3 (or X6 or T1) is defined from the Vessel ID & the next closest in time X2 (or T2) record.

STEP 5. Develop a new record for every (X3, X2), (X6, X2), (T1, T2) pair.

contnum	date of "arrival" (X3, X6, T1)	date of loading (X2, T2)	vessel ID	voyage#	carrier

STEP 6. Sort by Vessel ID, Date and Time of load, Company, *Contnum*, Voyage#.

STEP 7. Find and assign a "Voyage Date" for each voyage. Use the last date & time of loading as an approximation of the voyage departure.

STEP 8. For each voyage, add voyage date to all records.

STEP 9. Calculate days in port for each container.

STEP 10. Aggregate information to develop the arrival distribution for a voyage.

STEP 11. Compose a general vessel profile from the available history voyages.

For Imports (Discharge)

Categories for Import Movements:

1. **In By Ship** (*Status* = I1) - **Out By Truck** (*Status* = I4)
2. **In By Ship** (*Status* = I1) - **Transshipment** (*Status* = T1)
3. **In By Ship** (Status = I1) - **Out By Rail** (*Status* = T1, *Vessel* = RA)
4. **In By Ship** (*Status* = I1) - **Stripped In Port** (*Status* = E5)

STEP 3. For an I1 (in by ship) record keep: Date & Time of arrival + Voyage#.

STEP 4. For a related I4 (or T1 or E5) record keep: Date & Time (of movement) + Vessel ID. The relation between I1 and I4 (or T1 or E5) is defined from the Vessel ID & the next closest in time record.

STEP 5. Develop a new record for every (I1, I4), (I1, T1), (I1, E5) pair.

Contnum	date of unloading (I1)	date of exiting port (I4, T1, E5)	vessel ID	voyage#	

STEP 6. Sort by Vessel ID, Date and Time of unload, Company, *Contnum*, Voyage#.

STEP 7. Find and assign a "Voyage Date" for each voyage. Use the first date & time of unloading as an approximation of voyage arrival.

STEP 8. For each voyage, add voyage date to all records.

STEP 9. Calculate days in port for each container.

STEP 10. Aggregate information to develop the pick-up distribution for a particular voyage.

STEP 11. Compose a general vessel profile from the available history voyages.

APPENDIX B

DATABASE TECHNICAL REPORT

This report describes the required manipulation of the *History File* in order to develop distributions of export and import containers arrival / pick-up for each voyage.

The project was developed in the Microsoft® Access 97, database environment and runs under WindowsNT®. The source code was written in Microsoft® Visual Basic for Applications (VBA).

B.1 Data File Description

The *History file* includes all the container movements that were initiated to advance either an export or an import shipment. The particular file that was provided by *Maher Terminals Inc.* covers the whole period from April 97 (4/1) to September 98 (9/30).

A container movement is described by a 201-character string line.

The file had approximately 1,100,000 lines/records, saved in fixed-width text format.

B.2 History File Manipulation

B.2.1 Import to MS Access

A new MS Access database was created and named: *<Demo.mdb>*. To open the file the Microsoft® Access 97 version is required. The prescribed text-file is imported to MSAccess through a predefined import specification. The specification is stored within the database file.

Table B.1 defines the parts of the string that are imported in MS Access. The imported strings are stored in 12 consecutive fields. The field dividing lines are specified and the text format is selected for all the fields.

Table B.1 *History File*: Fixed Width Import to MS Access

Number of Field #	Start at Digit #	Number of Digits #	Cumulative Number of Digits #	Field Name	Description (Format)
1	3	1	3	Company	Company X
2	4	10	13	Contnum	Container AlphaNumeric #
3	15	6	20	DateOld	Date of Move yymmdd
4	21	4	24	TimeOld	Time of Movement hhmm
5	25	2	26	Status	Type of Movement XX
6	49	2	50	Vessel	Vessel Code XX
7	51	2	52	FirstPort	First port of call XX
8	64	1	64	Length	Container Length X
9	65	1	65	Description	Container Description X
10	66	5	70	Weight	Container Weight XXXXX
11	79	5	83	Carrier	Assigned Carrier XXXXX
12	171	5	175	Voyage	Voyage AlphaNumeric #

The import process is implemented through a VBA subroutine.

Module: TextImport
VBA Subroutine: ImportText
Input Recordset: *History File* in text format
Output Recordset: ***HistoryFile*** table

The subroutine reads the specified text file and imports the string parts in a table named ***HistoryFile.*** If the file does not meet the import specification (i.e. it is not a *History File*) the process terminates with no further continuation.

B.2.2 Change Date/Time Format

The date and the time of each movement are stored in ***HistoryFile*** table in the *DateOld* & *TimeOld* fields. Both these fields are in text format.

The date string is in yymmdd format. This format is not predefined in MS Access and the software interprets it as long integer. The same holds for the time string.

In order to perform calculations with dates and times the strings are broken up and reassembled using the `DateSerial` and `TimeSerial` `VBA` functions.

`Module: DateTimeFormat`
`VBA Subroutine: ChangeDateTimeFormat`
Input Recordset: ***HistoryFile*** table
Output Recordset: ***AllFinal*** table

In the new created table the date and time fields are named *DateNew* and *TimeNew* respectively. The rest of the fields remained unaltered during this procedure and are just copied in the new ***AllFinal*** table.

B.2.3 Split into Imports and Exports

Due to the intrinsic differences in the approach developed for imports and exports respectively the corresponding movements were split into two new tables. The new tables are designed identically to the ***AllFinal*** table.

The task is performed through a `VBA` subroutine that evaluates for each record the value of the *Status* field.

`Module: SplitImpoExpo`
`VBA Subroutine: SplitImportsExports`
Input Recordset: ***AllFinal*** table
Output Recordsets: ***Import*** table
Export table

According to the predefined coding scheme in the ***Import*** table are stored all the movements/records for whom the value of field *Status* = I1, I4, E5, T1.

Similarly in the ***Export*** table are stored all the movements/records for whom the value of field *Status* = X3, X2, X6, T1, T2.

The transshipment movements are dealt as both an export and an import movement. The following fields are dropped: *FirstPort, Length, Description and, Weight.*

B.2.4 Link Records

Each container transport movement through the port is captured by two separate events. The first event monitors the container entering the port (In Event). The second event monitors the container exiting the port (Out Event).

In ***Import*** and ***Export*** tables the two events are stored in two separate records. To evaluate the time-related characteristics of each container movement the two records were merged into a single one. This is made through a procedure that matches all the related records based on certain logical criteria and sorting properties.

The task is done by two separate `VBA` subroutines, for imports and exports respectively.

Procedure for Imports:

> `Module: ImpoJointMoves`
> `VBA Subroutine: ImpoMakePairs`
> Input Recordset: ***Import*** table
> Output Recordset: ***ImpoJointRec*** table

The merge scheme is depicted in Table B.2 that defines the relation between the fields of the new ***ImpoJointRec*** table with the fields of the merged records from the ***Import*** table.

Procedure for Exports:

```
Module: ExpoJointMoves
VBA Subroutine: ExpoMakePairs
```

Input Recordset: ***Export*** table
Output Recordset: ***ExpoJointRec*** table

The merge scheme is identical to the one used for imports. The procedure is quite similar with the one used for the imports.

Table B.2 Records Merging Scheme

Fields of ***ImpoJointRec*** Table	Fields of ***Import*** Table
Company	*Company* from In Event
Contnum	*Contnum* from In Event
InDate	*DateNew* from In Event
OutDate	*DateNew* from Out Event
InStatus	*Status* from In Event
OutStatus	*Status* from Out Event
InVessel	*Vessel* from In Event
InVoyage	*Voyage* from In Event
InCarrier	*Carrier* from In Event
InTime	*TimeNew* from In Event
OutVessel	*Vessel* from Out Event
OutVoyage	*Voyage* from Out Event
OutCarrier	*Carrier* from Out Event
OutTime	*TimeNew* from Out Event

B.2.5 Sort Tables

Up to this point the initial sorting was kept intact. All the tables were sorted according to the following field sequence:

Company – Contnum – DateNew(Ascending) – Time

However to employ the next procedure a new sorting is required.

Sort for Imports:

The ***ImpoJointRec*** table is sorted by:

Vessel – InDate(Ascending) – Company – Contnum - InVoyage

The sorted table is saved under a new name as ***ImportPairs*** to preserve the necessary record sorting.

`Module: SortImpoJointRec`
`VBA Subroutine: SortImpo`
Input Recordset: ***ImpoJointRec*** table
Output Recordset: ***ImportPairs*** table

Sort for Exports:

The ***ExpoJointRec*** table is sorted by:

Vessel – OutVoyage – OutDate(Descending) – Company – Contnum

The sorted table is saved under a new name as ***ExportPairs*** to preserve the necessary record sorting.

`Module: SortExpoJointRec`
`VBA Subroutine: SortExpo`
Input Recordset: ***ExpoJointRec*** table
Output Recordset: ***ExportPairs*** table

B.2.6 Find and Assign a "Voyage Date"

In this procedure for every vessel and for each voyage a "voyage date" is assigned to all the container-move records that are related with that particular voyage.

Procedure for Imports

For the imports section the voyage date is approximated by the first date of unloading.

> `Module: ImpoVoyageDate`
> `VBA Subroutine: ImpoSetVoyageDate`
> Input Recordset: ***ImportPairs*** table
> Output Recordset: ***ImpoVoyages*** table

The days in port for each container are calculated by the numerical subtraction of the Voyage Date from the OutDate value.

The new table *ImpoVoyages* has two additional fields named as *VoyageDate* and *DaysInPort* to store for all records the assigned values.

Procedure for Exports

For the exports section the voyage date is approximated by the last date of loading.

> `Module: ExpoVoyageDate`
> `VBA Subroutine: ExpoSetVoyageDate`
> Input Recordset: ***ExportPairs*** table
> Output Recordset: ***ExpoVoyages*** table

The days in port for each container are calculated by the numerical substraction of the *InDate* value from the *VoyageDate*.

The new table *ExpoVoyages* has two additional fields named as *VoyageDate* and *DaysInPort* to store for all records the assigned values.

B.3 Database Query – Analysis

The *History File* manipulation (§ B.2) facilitates the integration of the existing data file to a basic database file. The system is capable of executing ad hoc queries based on the existing fields and with criteria specified by the user. For simple select queries, no programming is required since the software provides an easy to use *Query Wizard.* However, to include characteristics of an information system and to accomplish data aggregation for the proposed forecasting models further automation of critical tasks is required.

B.3.1 Voyage Analysis

The initial step on developing the proposed container arrival pattern is to extract the information with regards to a particular voyage in the past.

The tables ***ImpoVoyages*** and ***ExpoVoyages*** created through the *History File* manipulation are the basis for the concurrent analysis, since all the required information is included in their fields.

Two consecutive VBA subroutines facilitate the select queries to apportion the containers associated to a particular voyage.

Imports:

> Module: FindImpoVoyages
> VBA Subroutine: OneImpoVessel
> Input Recordset: ***ImpoVoyages*** table
> Output Recordset: ***ImpoVoyageDataSet*** table

`Module: FindImpoSingle`
`VBA Subroutine: SingleImpoVoyage`
Input Recordset: ***ImpoVoyageDataSet*** table
Output Recordset: ***ImpoSingleDataSet*** table

Exports:

`Module: FindExpoVoyages`
`VBA Subroutine: OneVessel`
Input Recordset: ***ExpoVoyages*** table
Output Recordset: ***ExpoVoyageDataSet*** table

`Module: FindExpoSingle`
`VBA Subroutine: SingleExpoVoyage`
Input Recordset: ***ExpoVoyageDataSet*** table
Output Recordset: ***ExpoSingleDataSet*** table

When the selection process is complete, additional functionality allows for data aggregation, by means of demand patterns throughout the period before and after the voyage.

Two independent `VBA` subroutines were implemented for imports and exports respectively.

Imports:

`Module: ImpoDataSheet`
`VBA Subroutine: GetImpoStatistics`
Input Recordset: ***ImpoSingleDataSet*** table
Output Recordset: ***ImpoVoyageStatistics*** table
ImportCounts table

Exports:

`Module: ExpoDataSheet`
`VBA Subroutine: GetExpoStatistics`
Input Recordset: ***ExpoSingleDataSet*** table
Output Recordset: ***ExpoVoyageStatistics*** table
ExportCounts table

B.3.2 General Vessel Profile

The voyage analysis as described previously provides a thorough insight in the historical pattern observed for a particular voyage. The proposed forecasting scheme requires the construction of a general distribution pattern of the daily arrivals for each vessel. This is done by aggregating the available information for individual past voyages and link them in a general profile. The general profile is constructed on demand through a fully automated procedure. The process draws information directly from the main database table, which suffices the demand for continuous updating. Thus at any time the model is capable of attaining the most recent data. With respect to user selections the system stores in a temporary database instance the information available on a particular vessel. This temporary file forms the basis on which the model is created. In addition, the user should have the option to exclude a particular voyage based on his/her experience.

The demand profile is generated in three steps:

1. The first step is identical to a procedure described in the previous paragraph and facilitates the data aggregation for each particular voyage that is to be incorporated in the model.
2. The second step is designed as intermediary step that fulfills the need to neutralize the particular voyage from its original context. This includes the removal of the idle days (weekends,holidays) to prevent unacceptable model distortions. That is to refer to a suitable denominator with respect to the analysis time frames.
3. The third step incorporates the available voyage patterns in a single model. The magnitude of each historic voyage in the newly constructed demand distribution pattern is governed by the total amount of movements for the particular voyage.

The process is coded in two separate VBA modules. The first module includes several subroutines called in sequence to complete the first two steps. The second module finalizes the process and generates the general profile. The actual code operation is highlighted in the remaining.

Again, the tables ***ImpoVoyages*** and ***ExpoVoyages*** created through the *History File* manipulation are the basis for the concurrent analysis, since all the required information is included in their fields.

For clarity only the export section analysis is described. The procedure for the import section is very similar.

A selection query stores the information associated to a particular vessel in a temporary database table.

> `Module: FindExpoVoyages`
> `VBA Subroutine: OneVessel`
> Input Recordset: ***ExpoVoyages*** table
> Output Recordset: ***ExpoVoyageDataSet*** table

A subroutine aggregates the data for each voyage with respect to type of movement and date of operation.

> `Module: MidExpoStats`
> `VBA Subroutine: ExpoMidStatistics`
> Input Recordset: ***ExpoVoyageDataSet*** table
> Output Recordset: ***AllExpoVoyageStats*** table
> ***ExportCounts*** table

A subroutine adds to ***AllExpoVoyageStats*** table a numeric field, which value is dictated by the actual day of the week (Sunday = 1, Monday = 2,...)

```
Module: MidExpoStats
VBA Subroutine: AddExpoWeekDay
```
Input Recordset: ***AllExpoVoyageStats*** table
Output Recordset: ***NewAllExpoStats*** table

A delete query deletes the empty records for which the date is either a Sunday or a Saturday.

```
Module: MidExpoStats
VBA Subroutine: DeleteExpoWeekends
```
Input Recordset: ***NewAllExpoStats*** table
Output Recordset: ***NewAllExpoStats*** table

A subroutine re-adjusts the remaining records in a standard manner. The field *DaysInPort* refers to days of operation from now on rather than to actual days.

```
Module: MidExpoStats
VBA Subroutine: ReAdjustExpoDate
```
Input Recordset: ***NewAllExpoStats*** table
Output Recordset: ***RevAllExpoStats*** table

A subroutine sorts the records in descending order of the *DaysInPort* field value.

```
Module: MidExpoStats
VBA Subroutine: SortExpoStatistics
```
Input Recordset: ***RevAllExpoStats*** table
Output Recordset: ***MidExpoStatistics*** table

With the completion of this procedure the aggregated data are formatted for the final step in developing the general vessel profile.

The last procedure involves the calculation of the averages for the daily demand for the different type of movements and for the past voyages that are to be included in the model.

The estimates are weighted with respect to the actual total volume of each voyage and are expressed as percentages of the total demand allocated over the period before or after the voyage for the export and import section respectively. The results are stored in a separate table for subsequent retrieval and display in tabular and graphical format.

A subroutine manipulates ***MidExpoStatistics*** table to finalize the results.

```
Module: AllExpoStats
VBA Subroutine: GetAllExpoStatistics
```
Input Recordset: ***MidExpoStatistics*** table
Output Recordset: ***AllExpoStatistics*** table

The information included in ***AllExpoStatistics*** table is used as reference to the expected demand allocation for the future voyages of the particular vessel under examination.

APPENDIX C

MODEL EVALUATION EXAMPLES

MODEL EVALUATION: Exports

Vessel Code:	A1	Voyage Date:	8/30/98

Actual Voyage Demand Distribution (Percentages %)

Days Before	Truck	Stuffed in Port	Transhipments	Totals
More	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
8	1.23	0.00	0.00	1.04
7	1.23	0.00	0.00	1.04
6	1.23	0.00	0.00	1.04
5	2.47	0.00	0.00	2.08
4	11.11	0.00	25.00	10.42
3	12.35	0.00	25.00	11.46
2	30.86	0.00	0.00	26.04
1	39.51	100.00	50.00	46.88
0	0.00	0.00	0.00	0.00

Correlation Coefficients CORREL(Actual, Projected)

	0.9815	0.9929

Model Projected Demand Distribution (Percentages %)

Days Before	pTruck	pStuffed in Port	pTransshipments	pTotals
More	4.04	0.00	0.00	3.47
10	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
7	0.45	0.00	0.00	0.39
6	1.35	0.00	0.00	1.16
5	5.62	0.00	0.00	4.83
4	8.31	0.00	0.00	7.14
3	13.71	0.00	0.00	11.78
2	25.17	24.62	87.50	26.06
1	41.12	75.38	12.50	44.98
0	0.22	0.00	0.00	0.19

Standard Error STEYX(Actual, Projected)

Stnd Error	2.68	1.81
Sqrd Error (Sum)	9.84	7.94

Figure C-1(a) Voyage Export Report (Vessel: Atlantic Concert)

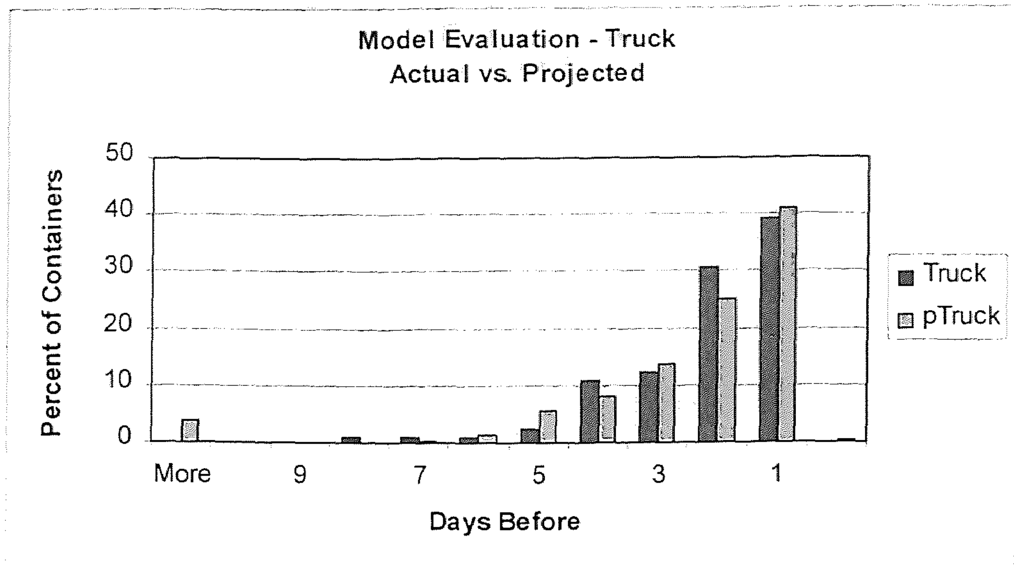


Figure C-1(b) Voyage Export Report (Vessel: Atlantic Concert)

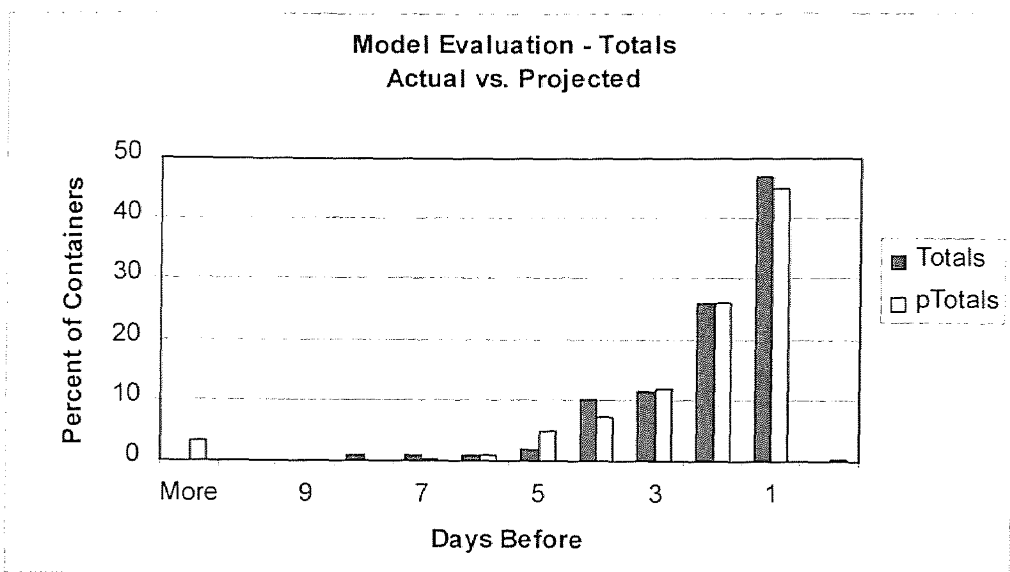


Figure C-1(c) Voyage Export Report (Vessel: Atlantic Concert)

MODEL EVALUATION: Exports

Vessel Code: D0 Voyage Date: 9/20/98

Actual Voyage Demand Distribution (Percentages %)				
Days Before	Truck	Stuffed in Port	Transhipments	Totals
More	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
8	1.01	0.00	0.00	1.01
7	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
5	9.09	0.00	0.00	9.09
4	17.17	0.00	0.00	17.17
3	22.22	0.00	0.00	22.22
2	16.16	0.00	0.00	16.16
1	34.34	0.00	0.00	34.34
0	0.00	0.00	0.00	0.00

Correlation Coefficients CORREL(Actual, Projected)				
	0.9628			0.9618

Model Projected Demand Distribution (Percentages %)				
Days Before	pTruck	pStuffed in Port	pTransshipments	pTotals
More	0.52	0.00	0.00	0.51
10	0.69	0.00	0.00	0.68
9	0.52	0.00	0.00	0.51
8	0.86	0.00	0.00	0.85
7	1.90	0.00	0.00	1.88
6	3.11	0.00	0.00	3.07
5	8.12	0.00	0.00	8.02
4	11.05	0.00	14.29	11.09
3	17.10	0.00	0.00	16.89
2	21.59	0.00	28.57	21.67
1	34.54	0.00	57.14	34.81
0	0.00	0.00	0.00	0.00

Standard Error STEYX(Actual, Projected)		
Stnd Error	3.29	3.33
Sqrd Error (Sum)	13.16	13.25

Figure C-2(a) Voyage Export Report (Vessel: Trade Apollo)

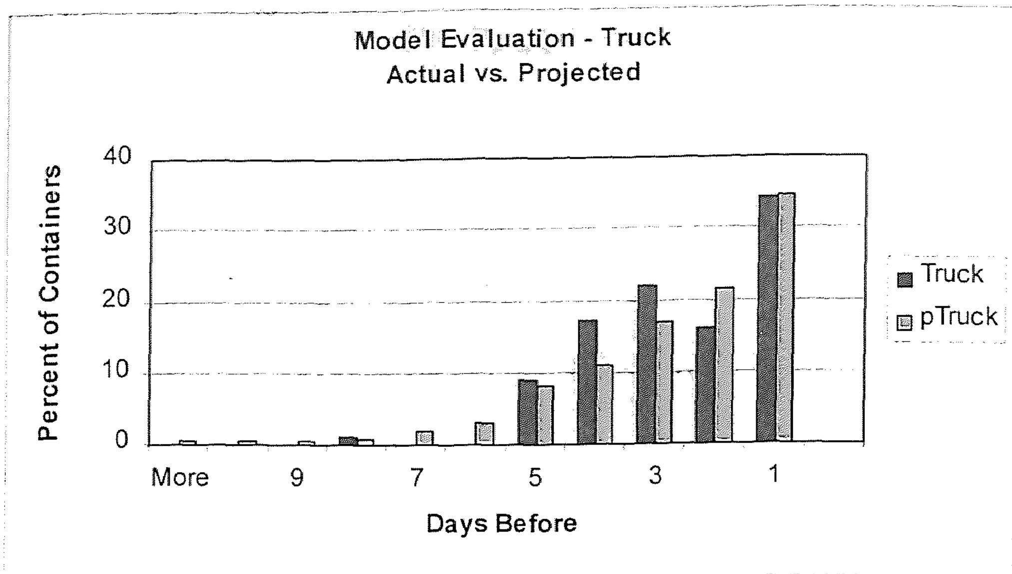


Figure C-2(b) Voyage Export Report (Vessel: Trade Apollo)

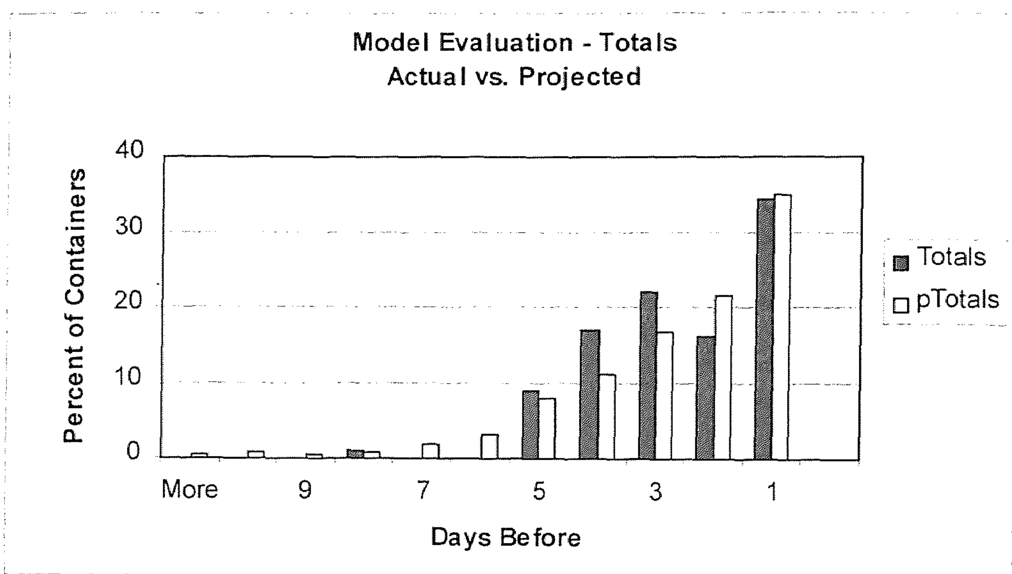


Figure C-2(c) Voyage Export Report (Vessel: Trade Apollo)

MODEL EVALUATION: Exports

Vessel Code: K8 **Voyage Date:** 9/12/98

Actual Voyage Demand Distribution (Percentages %)

Days Before	Truck	Stuffed in Port	Transhipments	Totals
More	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
9	7.84	0.00	0.00	7.55
8	9.80	0.00	0.00	9.43
7	7.84	0.00	100.00	11.32
6	11.76	0.00	0.00	11.32
5	0.00	0.00	0.00	0.00
4	7.84	0.00	0.00	7.55
3	9.80	0.00	0.00	9.43
2	27.45	0.00	0.00	26.42
1	17.65	0.00	0.00	16.98
0	0.00	0.00	0.00	0.00

Correlation Coefficients CORREL(Actual, Projected)

	0.8575			0.8332

Model Projected Demand Distribution (Percentages %)

Days Before	pTruck	pStuffed in Port	pTransshipments	pTotals
More	1.45	0.00	0.00	1.41
10	3.62	0.00	0.00	3.52
9	4.35	0.00	0.00	4.23
8	2.17	0.00	0.00	2.11
7	2.90	0.00	0.00	2.82
6	10.87	0.00	0.00	10.56
5	4.35	0.00	0.00	4.23
4	13.77	0.00	0.00	13.38
3	15.22	0.00	0.00	14.79
2	27.54	100.00	0.00	28.87
1	13.77	0.00	100.00	14.08
0	0.00	0.00	0.00	0.00

Standard Error STEYX(Actual, Projected)

Stnd Error	4.45			4.63
Sqrd Error (Sum)	53.09			68.15

Figure C-3(a) Voyage Export Report (Vessel: Empress Heaven)

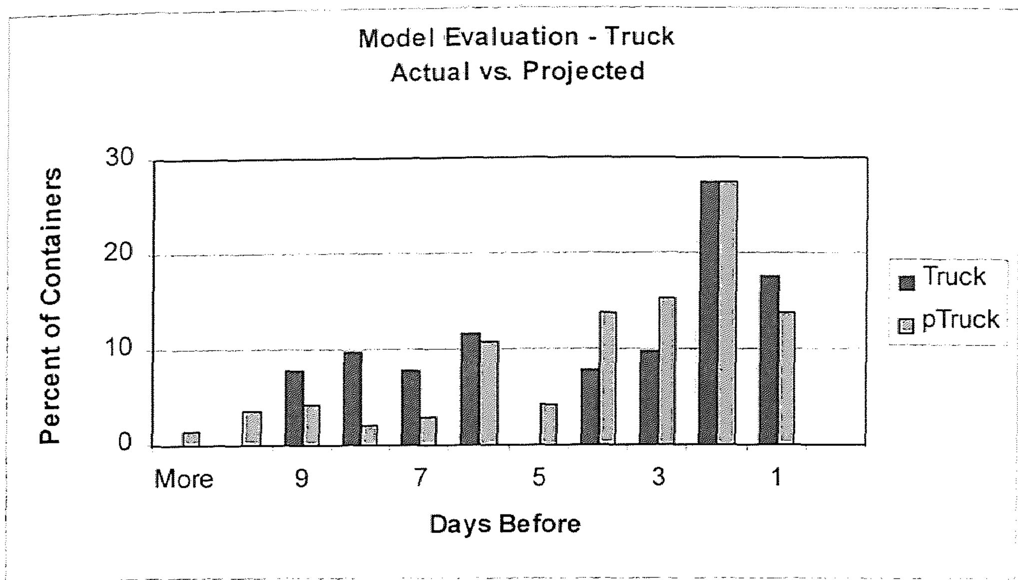


Figure C-3(b) Voyage Export Report (Vessel: Empress Heaven)

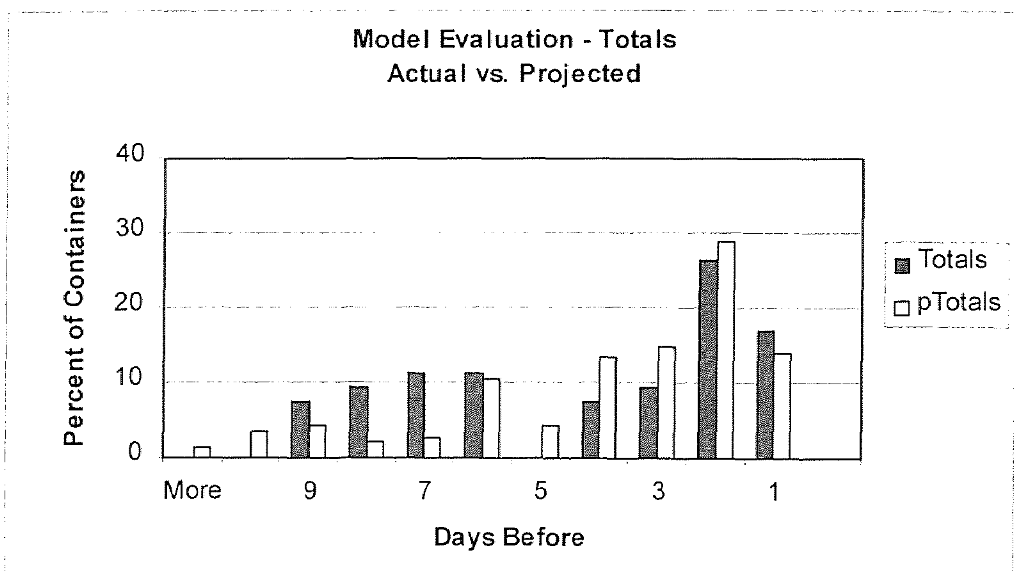


Figure C-3(c) Voyage Export Report (Vessel: Empress Heaven)

MODEL EVALUATION: Imports

Vessel Code:	A1	Voyage Date:	8/24/98

Actual Voyage Demand Distribution

Days After	Imports	Striped in Port	Totals
0	1.02	0.00	0.90
1	13.20	0.00	11.76
2	21.32	0.00	19.00
3	17.26	4.17	15.84
4	11.68	91.67	20.36
5	21.32	0.00	19.00
6	2.03	0.00	1.81
7	3.55	0.00	3.17
8	2.54	0.00	2.26
9	2.03	4.17	2.26
10	0.00	0.00	0.00
More	4.06	0.00	3.62

Correlation Coefficients CORREL(Actual, Projected)

	0.8098		0.8330

Model Projected Demand Distribution

Days After	pImports	pStriped in Port	pTotals
0	1.81	0.00	1.69
1	24.06	0.00	22.45
2	19.79	41.38	21.23
3	13.55	11.49	13.41
4	14.86	28.74	15.79
5	11.25	0.00	10.50
6	6.32	0.00	5.90
7	3.45	0.00	3.22
8	1.48	1.15	1.46
9	1.89	6.90	2.22
10	0.82	0.00	0.77
More	0.74	10.34	1.38

Standard Error STEYX(Actual, Projected)

Stnd Error	5.01		4.73
Sqrd Error (Sum)	35.53		22.03

Figure C-4(a) Voyage Import Report (Vessel: Atlantic Concert)

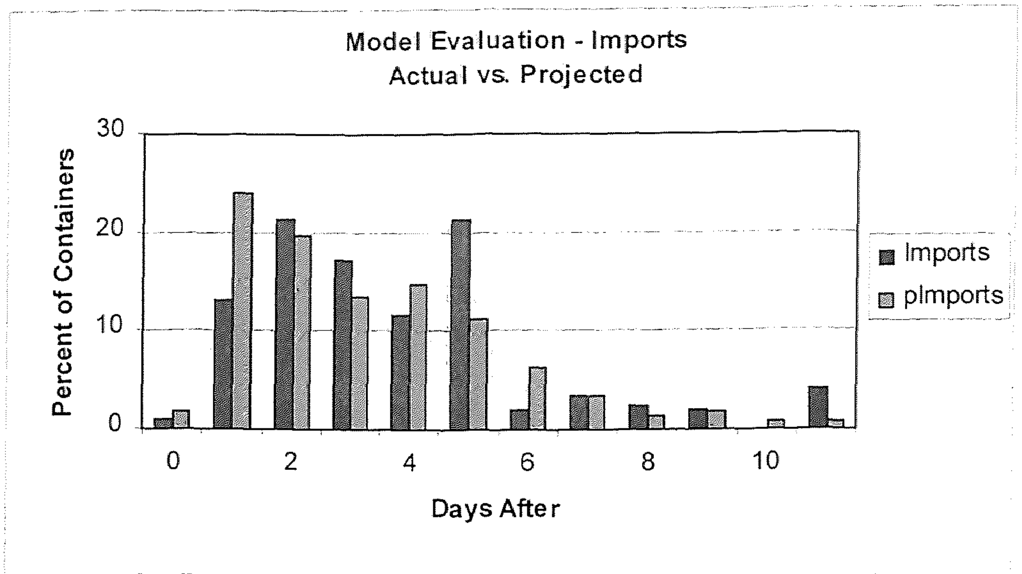


Figure C-4(b) Voyage Import Report (Vessel: Atlantic Concert)

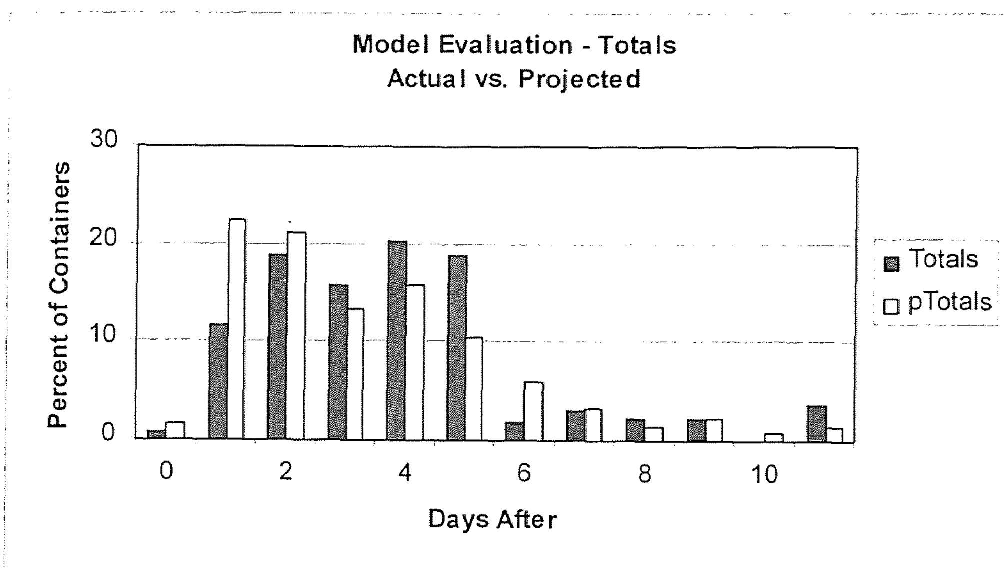


Figure C-4(c) Voyage Import Report (Vessel: Atlantic Concert)

MODEL EVALUATION: Imports

Vessel Code:	D0	Voyage Date:	9/14/98

Actual Voyage Demand Distribution

Days After	Imports	Striped in Port	Totals
0	0.00	0.00	0.00
1	13.40	0.00	13.40
2	20.41	0.00	20.41
3	16.11	0.00	16.11
4	12.44	0.00	12.44
5	13.08	0.00	13.08
6	7.97	0.00	7.97
7	5.90	0.00	5.90
8	2.07	0.00	2.07
9	4.47	0.00	4.47
10	3.83	0.00	3.83
More	0.32	0.00	0.32

Correlation Coefficients CORREL(Actual, Projected)

	0.9465		0.9464

Model Projected Demand Distribution

Days After	pImports	pStriped in Port	pTotals
0	4.49	0.00	4.49
1	14.44	0.00	14.43
2	19.80	0.00	19.80
3	16.72	0.00	16.72
4	13.11	0.00	13.10
5	12.26	0.00	12.26
6	5.90	0.00	5.90
7	5.62	0.00	5.62
8	2.34	0.00	2.34
9	1.53	0.00	1.52
10	0.90	0.00	0.90
More	2.88	100.00	2.91

Standard Error STEYX(Actual, Projected)

Stnd Error	2.25	2.25
Sqrd Error (Sum)	22.87	22.91

Figure C-5(a) Voyage Import Report (Vessel: Trade Apollo)

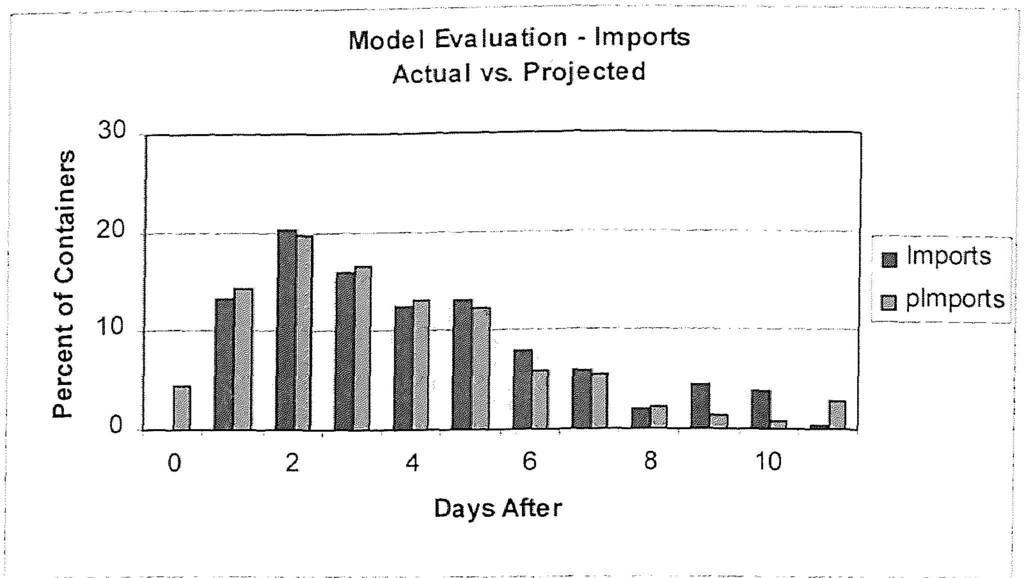


Figure C-5(b) Voyage Import Report (Vessel: Trade Apollo)

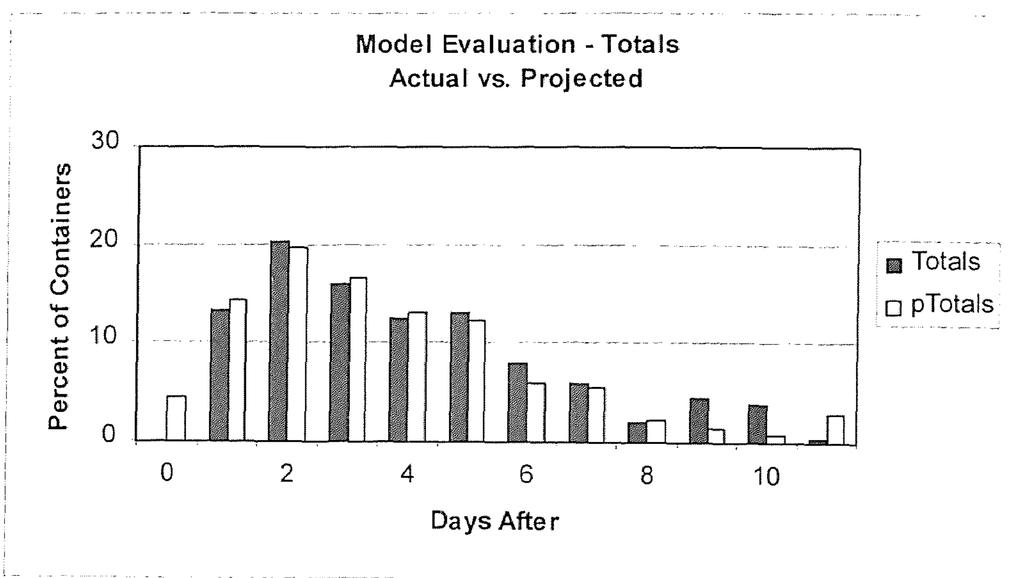


Figure C-5(c) Voyage Import Report (Vessel: Trade Apollo)

MODEL EVALUATION: Imports

Vessel Code:	K8	Voyage Date:	9/11/98

Actual Voyage Demand Distribution

Days After	Imports	Striped in Port	Totals
0	0.00	0.00	0.00
1	7.74	0.00	7.74
2	11.45	0.00	11.45
3	15.32	0.00	15.32
4	12.26	0.00	12.26
5	13.39	0.00	13.39
6	9.84	0.00	9.84
7	17.10	0.00	17.10
8	5.32	0.00	5.32
9	1.94	0.00	1.94
10	3.39	0.00	3.39
More	2.26	0.00	2.26

Correlation Coefficients CORREL(Actual, Projected)

	0.8057	0.8057

Model Projected Demand Distribution

Days After	pImports	pStriped in Port	pTotals
0	0.08	0.00	0.08
1	14.57	0.00	14.57
2	16.83	0.00	16.83
3	14.24	0.00	14.24
4	12.73	0.00	12.73
5	8.88	0.00	8.88
6	10.05	0.00	10.05
7	12.40	0.00	12.40
8	2.35	0.00	2.35
9	1.34	0.00	1.34
10	0.67	0.00	0.67
More	5.86	0.00	5.86

Standard Error STEYX(Actual, Projected)

Stnd Error	3.55	3.55
Sqrd Error (Sum)	26.46	26.46

Figure C-6(a) Voyage Import Report (Vessel: Empress Heaven)

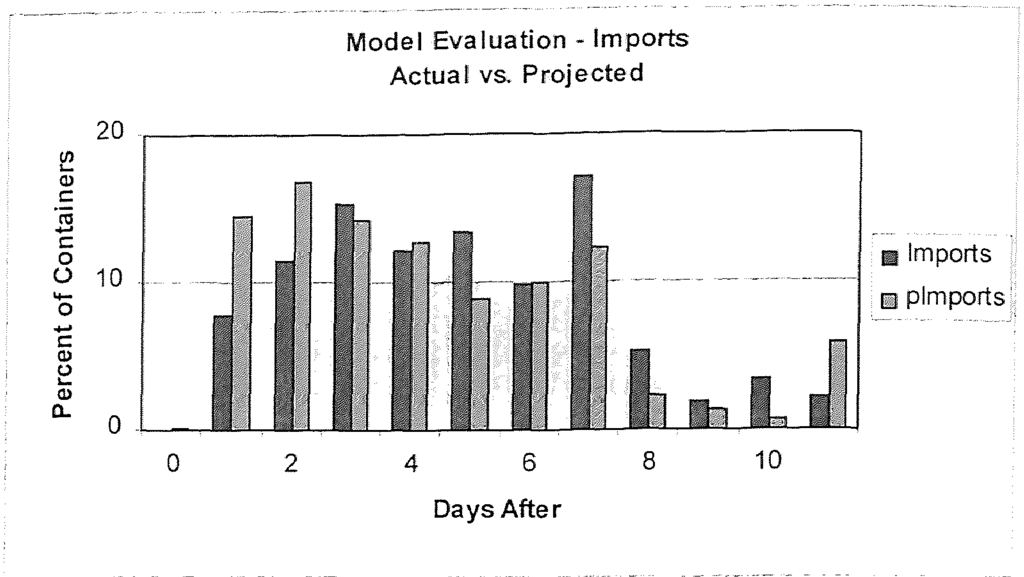


Figure C-6(b) Voyage Import Report (Vessel: Empress Heaven)

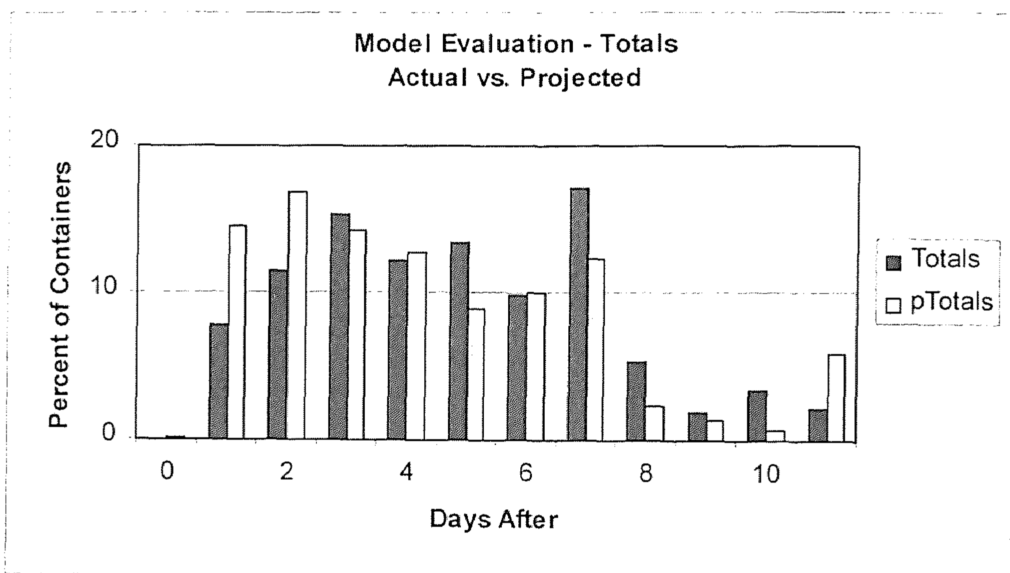


Figure C-6(c) Voyage Import Report (Vessel: Empress Heaven)

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