

Contribution margin model applied to the marketing planning of a container liner carrier

G A A Costa*, M A Brinati, and C M Hino

Department of Naval Engineering, Escola Politécnica da Universidade de São Paulo, São Paulo, Brazil

The manuscript was received on 4 March 2008 and was accepted after revision for publication on 16 September 2008.

DOI: 10.1243/14750902JEME109

Abstract: The implementation of confidential contracts between a container liner carrier and its customers, because of the Ocean Shipping Reform Act (OSRA) 1998, demands a revision in the methodology applied in the carrier's planning of marketing and sales. The marketing and sales planning process should be more scientific and with a better use of operational research tools considering the selection of the customers under contracts, the duration of the contracts, the freight, and the container imbalances of these contracts are basic factors for the carrier's yield. This work aims to develop a decision support system based on a linear programming model to generate the business plan for a container liner carrier, maximizing the contribution margin of its freight.

Keywords: liner service, contribution margin, container, decision support system

1 INTRODUCTION

Over the last few years, the container liner industry has been concentrated in a smaller number of carriers while the capacity of the ships continues to increase, targeting economies of scale [1]. The concentration process has not reduced the competition in the industry but has increased it, mainly due to the expansion of the largest carriers' activities in new routes and markets in addition to their traditional ones. This competition results in a reduction of the profit margins of the industry and forces the carriers to adopt predatory commercial policies in case the demand is smaller than the tonnage deployed. In extreme cases, the carriers tend to practice freight levels close to, or the same as, their short-term marginal costs. The carriers also search for cargoes in the general cargoes market (normally break bulk commodities) that can be containerized in order to increase the transport demand. In periods when the demand is the same or larger than the transport capacity, the carriers adopt freight levels that the market can support. In extreme cases,

some cargoes – mainly those considered commodities – stop being containerized and return to the market of general cargoes.

The competition in this industry also increased after the publication by the North American Congress, in November 1998, of the Ocean Shipping Reform Act (OSRA). This Act changed the relationship between carriers and their customers, reducing the power of the freight conferences and increasing the use of confidential contracts among the parties [2]. Its effects were not restricted to the American traffic and they affected the way that the freight conferences or carrier discussion agreements determined the competition level among liner carriers worldwide. The need to develop commercial relationships based on confidential contracts significantly changed the marketing and sales processes of the carriers [3]. Presently, there is a larger concern with respect to the forecasting of the demand, and a broader knowledge about the main customers' performance and/or cargoes in foreign trade. The liner carriers must change their marketing and sales processes to cope with the new competitive environment created by the OSRA.

The analyses of this change in a carrier and the development of this work are based on the practical experience in a liner carrier operating in the Europe–

*Corresponding author: Department of Naval Engineering, Escola Politécnica da Universidade de São Paulo, São Paulo, Brazil. email: gustavo.costa@sao.hamburgsud.com

South America trade region. This carrier has two departments with responsibilities for marketing and sales management: the product management department and the sales department.

1.1 Product management department

This department is responsible for: services management (routes and ships deployment); market and competition analyses; development and management of the portfolio of clients; pricing policy and bids coordination; service performance in terms of volume, revenue, and contribution margin; and business plan development and management. It also has marketing intelligence functions, which can be summarized as the process of gathering internal and external data, and the organization, analysis, and dissemination of information that is important to the business plan development.

1.2 Sales department

This department is responsible for achieving the business plan goals as revenue, volume, and contribution per client. It also provides the product management department with the clients' expectations of the services rendered by the carrier. In order to achieve the goals, the sales personnel have to negotiate with the clients, focusing on the freight level and volume.

1.3 Business plan

The product management department develops the business plan considering the past performance of the foreign trade among the regions and the trends input from the marketing intelligence group. There is also the input from the carrier top management with the goals of revenue and contribution for the service.

The business plan developed consists of the selection of clients, and respective cargoes, in each port of call that maximizes the carrier's profit. This selection determines the portfolio of clients that should be constantly managed by the sales department along the planning horizon of the business plan. The portfolio of clients includes those whom the carrier should have service contracts with – due to their regular sizeable shipments – and clients without contracts that do not have the same regularity in their shipments or a significant number of cargoes.

It was noticed that the carrier's business plan is managed in a decentralized manner and under the responsibility of each regional office (Europe and South America), being managed with exclusive focus on the exports of each region. The two business plans are consolidated in the carrier's central office in Europe at a later stage. There is also a dispute for transport capacity regarding the flows of full and empty containers. A degree of dispute among the regional offices has been detected for the use of the transport capacity just with full containers. In cases where a region has a surplus of a certain type of empty container and at the same time a high export demand that does not require this container type, this region will not agree to use the transport capacity to position empty containers for the other region to the detriment of its own export flows. This dispute among the regions creates difficulties and challenges for the logistics department when carrying out its logistics planning for empty container positioning.

The model developed in this paper allows the carrier to modify its business plan process, making it more independent of the commercial pressures of each regional office, by selecting the cargoes that maximize its contribution margin. The model also includes the logistics of empty containers in the process, decreasing disputes regarding transport capacity among the regions. The paper is structured as follows. In section 2, a decision support system (SADE) for the business plan process is proposed. Section 3 formulates an optimal business plan model through linear programming. Section 4 presents application scenarios and a discussion, followed by concluding remarks in section 5.

2 DECISION SUPPORT SYSTEM – SADE

Figure 1 presents a model of a carrier information system with the SADE (initials of Strategic Decision Support System in Portuguese) system integrated to it. Its basic components are as follows.

1. Customer relationship management (CRM): contains the clients' past performance data in terms of amount of business and revenue generated per period.
2. Marketing and sales system: contains the clients' contracts or negotiation data giving details of freight, taxes, minimum and maximum commitment and duration of contracts. It also contains the relationships between clients and cargoes, cargo type and container type, and the container weight per cargo type.

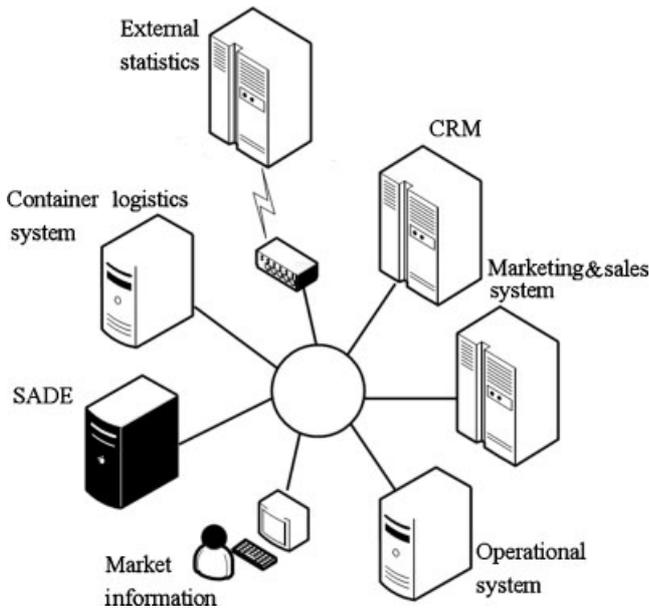


Fig. 1 Carrier information system with SADE

3. Operational system: contains the ports' data in terms of loading and discharging costs of full and empty containers, port call costs, and operational constraints. It also contains the ships' operational data.
4. Container logistics system: contains the data of empty container logistics as inland transportation costs, handling costs in the empty container terminals, and maintenance and repair costs. It also contains the container fleet data and the empty container terminal constraints.
5. External statistics: this represents the link with external data, mainly statistical data such as cargoes and clients, the number of containers in the import and export flows, market share per carrier, cargo type, port pairs, cargo weight, container type, etc.
6. Market information: this represents the interface with the associations or entities representative of industrial sectors or governmental agencies.

The SADE system can be used for the analysis of different scenarios, in which the commercial and/or operational conditions can be varied, with the objective of maximizing the contribution margin. The result of that analysis generates the list of cargoes, customers, and number of containers per port pair in the planning horizon of the business plan.

3 PROBLEM DEFINITION AND ASSUMPTIONS

The problem is defined in the following way: given a route, a fleet of homogeneous ships, the demand, the

revenues and costs related to the full container operations, and the costs related to the empty container logistics, a portfolio of clients should be determined that maximizes the contribution margin of the carrier in the planning horizon of the business plan. Figure 2 represents the description of the problem.

The operational and cost data for the route (port of calls), ships, and empty container logistics are obtained from the carrier's systems. The demand and revenue data are deterministic and are based on past performance data and trends analysis developed in the marketing intelligence studies carried out by the product management department. The original demand data include 1854 clients in the Brazilian export data and 2807 clients in the European export data. The present model could not process the database of clients, with 4661 clients,

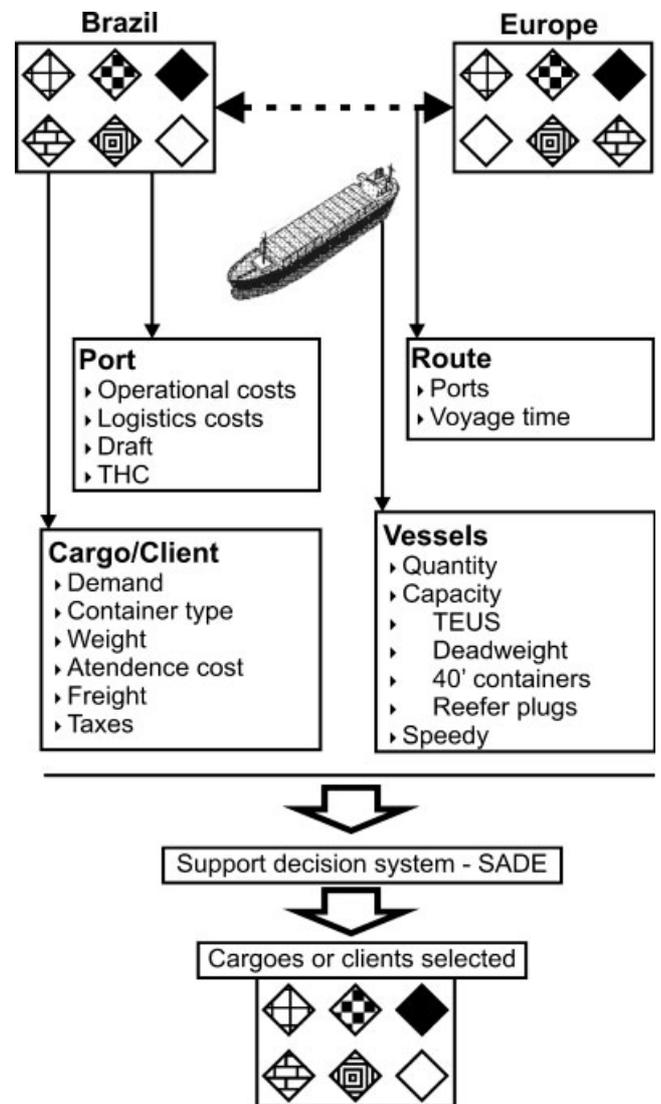


Fig. 2 Problem description

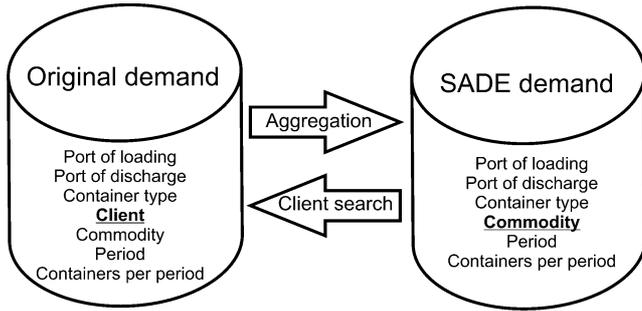


Fig. 3 Demand data aggregation

and it was necessary to reduce the size of the demand matrix. In order to overcome this problem, the model processes new demand data aggregated by the two digits of the harmonized commodity code. The new demand database has 99 commodities as the new primary demand data. As the model output gives the commodity flow per period, it is possible to create the portfolio of clients by searching the original demand database using loading port, discharging port, commodity, and period as the searching keys, and selecting the respective clients. Figure 3 represents the aggregation and client searching processes.

3.1 SADE model

The mathematical model is developed in a linear program, using the concepts of capacity management, empty container logistics, and contribution margin maximization.

Notation

The indices used in the development of the mathematical model are shown in Table 1.

Table 1 Indices used in the mathematical model

Index	Definition
p	Index of all ports in the model
i	Index of the port in a loading condition
j	Index of the ports in a discharging condition
k	Index of container types
c	Index of cargo type classification
t	Index of period
δ	Index of predecessor periods of the period with index t
P	Set of all ports
I	Set of all loading ports
J	Set of all discharging ports
K	Set of all container types
K^R	Subset of K ($K^R \subset K$) with all containers of reefer type
K^F	Subset of K ($K^F \subset K$) with all container of 40 ft size
C	Set of all cargo types
T	Set of all periods

Parameters

The parameters used in the mathematical model are given in Table 2.

Decision variables

The decision variables composing the proposed mathematical model are given in Table 3.

Objective function

$$\begin{aligned}
 C^T = & \left[\sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{c \in C} \sum_{t \in T} (R_{i,j,k,c,t}^F F_{i,j,k,c,t}^F) \right. \\
 & - \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{c \in C} \sum_{t \in T} (C_{i,j,k}^F F_{i,j,k,c,t}^F) \\
 & - \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{c \in C} \sum_{t \in T} (C_c^M F_{i,j,k,c,t}^F) \\
 & - \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{t \in T} (C_{i,j,k}^E F_{i,j,k,t}^E) \\
 & \left. - \sum_{j \in J} \sum_{k \in K} \sum_{t \in T} (C_k^S E_{j,k,t}) \right] \quad (1)
 \end{aligned}$$

The parameters in parentheses in equation (1) represent, respectively, the revenue, the costs of loading and discharging of full containers, the costs to attend the cargo types, the costs of loading and discharging of empty containers, and the costs of empty container storage.

Constraints

The decision variables are subjected to the following constraints.

1. Maximum share of the carrier in the cargo type – this constraint limits the maximum expected share of the carrier in the cargoes types.

$$F_{i,j,k,c,t}^F \leq [P_{c,t}^X D_{i,j,k,c,t}^F] \quad (2)$$

for $\forall i \in I, \forall j \in J, \forall k \in K, \forall c \in C, \forall t \in T$. The function $f(x) = |x|$ was used in this equation, returning the greater integer less than equal to x .

2. Minimum share of the carrier in the cargo type – this constraint limits the minimum expected share of the carrier in the cargo types.

$$F_{i,j,k,c,t}^F \geq [P_{c,t}^L D_{i,j,k,c,t}^F] \quad (3)$$

for $\forall i \in I, \forall j \in J, \forall k \in K, \forall c \in C, \forall t \in T$.

Table 2 Parameters used in the mathematical model

Parameter	Definition
$D_{i,j,k,c,t}^F$	The demand from the loading port i to the discharging port j of containers of type k with cargo of type c in the period t
$R_{i,j,k,c,t}^F$	The revenue (freight and taxes) obtained when transporting from the loading port i to the discharging port j a container of type k with cargo of type c , in the period t
$C_{i,j,k}^F$	The cost of loading at port i and discharging at port j a container of type k , with some cargo
$C_{i,j,k}^E$	The cost of loading at port i and discharging at port j an empty container of type k
C_c^M	The attendance cost for cargo type c
C_k^S	The storage cost for one container of type k , for one period
$W_{k,c}^F$	The average weight of one container of type k with cargo of type c
W_k^E	The average weight of one empty container of type k
H_p	The maximum cargo deadweight in the port of index p
$M_{p,i,j}$	The predecessor matrix. This matrix indicates, with binary values, if at the entrance of port p , a container loaded at port i with destination to port j is on board of the ship. That is, $M_{p,i,j} = 1$, if one container loaded in the port i with destination to the port j is on board when the ship arrives at the port p , and zero otherwise
$S_{j,i,k,\delta}^F$	The fraction of containers of type k that, loaded full in port i and discharged in port j , returns empty to the empty container terminal of port j after δ periods of time, counted from the loading time at port i . It is assumed that the liner carrier has an empty container terminal close to each port j of the route. For simplification, it is referred to as empty container terminal of port j . In order to keep the general balance of the model, the following relation must be satisfied
	$\sum_{\delta \in \Delta} S_{j,i,k,\delta}^F = 1 \quad \text{para } \forall j \in J, \forall i \in I, \forall k \in K \quad (4)$
$S_{j,i,k,\delta}^E$	The fraction of containers of type k that, loaded empty in port i and discharged in port j , becomes available for utilization at the empty container terminal of port j after δ periods of time, counted from the loading time at port i . In order to keep the general balance of the model, the following relation must be satisfied
	$\sum_{\delta \in \Delta} S_{j,i,k,\delta}^E = 1 \quad \text{para } \forall j \in J, \forall i \in I, \forall k \in K \quad (5)$
$L_{j,k,\delta}^F$	The fraction of containers of type k that, released for export at the empty container terminal of port j , arrives full to this port after δ periods, counted from the release time. In order to keep the general balance of the model, the following relation must be satisfied
	$\sum_{\delta \in \Delta} L_{j,k,\delta}^F = 1 \quad \text{para } \forall j \in J, \forall k \in K \quad (6)$
$L_{j,k,\delta}^E$	The fraction of containers of type k that, released for empty positioning at the empty container terminal of port j , arrives empty at this port after δ periods, counted from the release time. In order to keep the general balance of the model, the following relation must be satisfied
	$\sum_{\delta \in \Delta} L_{j,k,\delta}^E = 1 \quad \text{para } \forall j \in J, \forall k \in K \quad (7)$
$P_{c,t}^X$	The maximum fraction of the carrier participation in the cargo type c in the period t
$P_{c,t}^I$	The minimum fraction of the carrier participation in the cargo type c in the period t
N^V	The number of ships allocated by the carrier to the route considered
T^C	The round trip time of the route, measured in periods of the set T
N^T	The ship capacity in twenty-foot equivalent units (TEUs)
N^D	The ship capacity in cargo deadweight
N	The maximum flow in TEUs between consecutive ports in one period of set T . It is a function of the number of ships and the round trip time of the route. N is calculated as:
	$N = \left(\frac{N^V N^T}{T^C} \right) \quad (8)$
N^P	The number of plugs for reefer containers in the ship
N^F	The ship capacity for 40 ft container stowage
N_i^E	The storage capacity of empty containers, in TEUs, in port i
N_k^C	The fleet size of available containers of type k
Q_k	The amount of TEUs occupied by one container of type k

Table 3 Decision variables composing the proposed mathematical model

Variables	Definition
C^T	Total contribution margin of the freights for the evaluated system
$F_{i,j,k,c,t}^F$	Number of containers of type k , with cargo of type c , loaded at port i in the period t to be discharged at port j
$F_{i,j,k,t}^E$	Number of empty containers of type k loaded at port i , in the period t , to be discharged at port j
$E_{i,k,t}$	Number of empty containers of type k , stored at port i , at the end of period t
$R_{p,t}$	Amount of TEUs on board the ship, at the entrance of the port of index p , in the period t . It represents the sum of the full and empty containers on board
$R_{i,k,t}^{SF}$	Number of empty containers of type k returned by the import clients to the empty container terminal of port i , in the period t
$R_{i,k,t}^{SE}$	Number of empty containers of type k that arrive to the empty container terminal of port i , in period t , due to empty container repositioning from other ports of the route
$R_{i,j,k,c,t}^{LF}$	Number of containers of type k , released from the empty container terminal of port i , in period t , to meet an export demand of cargo of type c to port j
$R_{i,j,k,t}^{LE}$	Number of empty containers of type k released from the empty container terminal of port i , in period t , to meet an empty container demand of port j

3. Balance of empty containers – this constraint represents the balance of empty containers at the empty container terminals of all ports of the route.

$$E_{i,k,t} = \left[E_{i,k,t-1} + R_{i,k,t}^{SF} + R_{i,k,t}^{SE} - \sum_{j \in J} \sum_{c \in C} R_{i,j,k,c,t}^{LF} - \sum_{j \in J} R_{i,j,k,t}^{LE} \right] \quad (9)$$

for $\forall i \in I, \forall k \in K, \forall t \in T$. The initial storage of empty containers is set free in order to be chosen by the model.

4. Calculation of the number of empty containers returned from import status – this constraint calculates how many empty containers are returned in the period t by the import clients, at each port, for each container type.

$$R_{i,k,t}^{SF} = \sum_{j \in J} \sum_{c \in C} \sum_{t' \in T} \left(S_{j,i,k,t-t'}^F F_{i,j,k,c,t'}^F \right) \quad (10)$$

for $\forall i \in I, \forall k \in K, \forall t \in T$.

5. Calculation of the number of empty containers of type k received at the empty container terminal port j , in the period t , due the repositioning of empty containers from other

ports of the route

$$R_{i,k,t}^{SE} = \sum_{j \in J} \sum_{t' \in T} \left(S_{j,i,k,t-t'}^E F_{i,j,k,t'}^E \right) \quad (11)$$

for $\forall i \in I, \forall k \in K, \forall t \in T$.

6. Calculation of the number of empty containers released for export – this constraint calculates how many empty containers are released for export in the period t , at each port, for each container type.

$$F_{i,j,k,c,t}^F = \sum_{t' \in T} \left(L_{i,k,t-t'}^F R_{i,j,k,c,t'}^{LF} \right) \quad (12)$$

for $\forall i \in I, \forall j \in J, \forall k \in K, \forall c \in C, \forall t \in T$.

7. Calculation of the number of empty containers released for repositioning – this constraint calculates how many empty containers are released for repositioning in the period t , at each port, for each container type.

$$F_{i,j,k,t}^E = \sum_{t' \in T} \left(L_{i,k,t-t'}^E R_{i,j,k,t'}^{LE} \right) \quad (13)$$

for $\forall i \in I, \forall j \in J, \forall k \in K, \forall t \in T$.

8. Maximum storage – this constraint limits the maximum number of containers, in TEUs, that can be stored at each port.

$$\sum_{k \in K} (E_{j,k,t} Q_k) \leq N_j^E \quad (14)$$

for $\forall j \in J, \forall t \in T$.

9. Flow capacity – calculation of the number of containers, in TEUs, on board the ships at the entrance of port p , in period t .

$$R_{p,t} = \left[\sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{c \in C} (\mathbf{M}_{p,i,j} Q_k F_{i,j,k,c,t}^F) + \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} (\mathbf{M}_{p,i,j} Q_k F_{i,j,k,t}^E) \right] \quad (15)$$

for $\forall p \in P, \forall t \in T$.

$$R_{p,t} \leq N \quad (16)$$

for $\forall p \in P, \forall t \in T$.

10. Maximum draft in the ports – this constraint limits the draft in each leg of the route.

$$\left[\sum_{i \in I} \sum_{j \in J} \sum_k \sum_{c \in C} \left(\mathbf{M}_{p,i,j} W_k^F c F_{i,j,k,c,t}^F \right) + \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \left(\mathbf{M}_{p,i,j} W_k^E F_{i,j,k,t}^E \right) \right] \leq \min \left\{ \frac{N^V H_p}{TC}, \frac{N^V H_{p'}}{TC} \right\} \quad (17)$$

for $\forall p \in P, p' | \text{predecessor of } p, \forall t \in T$.

11. Number of full reefer containers on board the ships – this constraint limits the number of full reefer containers on board the ships, due to the number of electrical plugs for reefer containers on the ships.

$$\sum_{i \in I} \sum_{j \in J} \sum_{k \in K^R} \sum_{c \in C} \left(\mathbf{M}_{p,i,j} F_{i,j,k,c,t}^F \right) \leq \left(\frac{N^V N^P}{TC} \right) \quad (18)$$

for $\forall p \in P, \forall t \in T$.

12. Number of 40 ft containers on board the ships – this constraint limits the number of 40 ft containers on board the ships, due to the stowage plan for this type of container.

$$\left[\sum_{i \in I} \sum_{j \in J} \sum_{k \in K^F} \sum_{c \in C} \left(\mathbf{M}_{p,i,j} F_{i,j,k,c,t}^F \right) + \sum_{i \in I} \sum_{j \in J} \sum_{k \in K^E} \left(\mathbf{M}_{p,i,j} F_{i,j,k,t}^E \right) \right] \leq \left(\frac{N^V N^F}{TC} \right) \quad (19)$$

for $\forall p \in P, \forall t \in T$.

13. Container fleet – this constraint sets an upper bound for the number of type k used in period t .

$$\left[\sum_{i \in I} \sum_{j \in J} \sum_{c \in C} F_{i,j,k,c,t}^F + \sum_{i \in I} \sum_{j \in J} F_{i,j,k,t}^E + \sum_{i \in I} E_{i,k,t} + \sum_{i \in I} \sum_{j \in J} \sum_{c \in C} \sum_{t' \in T} \sum_{\delta > (t'-t)} \left(S_{j,i,k}^F \delta F_{i,j,k,c,t'}^F \right) + \sum_{i \in I} \sum_{j \in J} \sum_{t' \in T} \sum_{\delta > (t'-t)} \left(S_{j,i,k}^E \delta F_{i,j,k,t'}^E \right) + \sum_{i \in I} \sum_{j \in J} \sum_{c \in C} \sum_{t' \in T} \sum_{\delta > (t'-t)} \left(L_{i,k}^F \delta R_{i,j,k,c,t'}^F \right) + \sum_{i \in I} \sum_{j \in J} \sum_{t' \in T} \sum_{\delta > (t'-t)} \left(L_{i,k}^E \delta R_{i,j,k,t'}^E \right) \right] \leq N_k^C \quad (20)$$

for $\forall k \in K, \forall t \in T$. The terms in equation (20) represent, respectively, the number of full containers on board, the number of empty containers on board, the number of empty containers at the empty container terminals, the number of containers driven to the import clients that have not yet arrived at the empty container terminals, the number of empty containers coming from others parts of the route that have not yet arrived at the empty container terminals, the number of containers released from the empty container terminal to export clients that have not yet arrived at the port, and the number of empty containers released from the empty container terminal for repositioning in other parts of the route that have not yet arrived at the loading port.

4 CASE STUDIES AND DISCUSSION

The case studies were developed based on different scenarios that represent some of the usual problems faced by a liner carrier. The model considers a carrier operating in the Brazil–Europe route (Fig. 4). The sequence in the ports of call forms the route and determines the loading and discharging order in the ports. The port of Santos is called at twice; once for discharging (southbound call) and once for loading of containers (northbound call). Five homogeneous ships are deployed on the route with a round trip of 35 days, resulting in a regular service with weekly calls in all ports of the route; therefore, there are four calls per port distributed in a period equal to

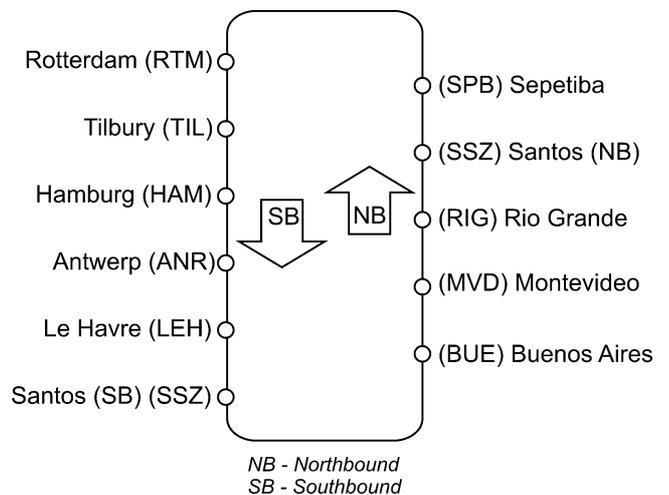


Fig. 4 Case study route

Table 4 Commodity codes

Commodity code and description	Model
00 Provisional code	C_00
02 Meat and edible meat offal	C_02
05 Products of animal origin, nos	C_05
06 Live trees, plants, bulbs, etc.; cut flowers, etc.	C_06
07 Edible vegetables, and certain roots and tubers	C_07
08 Edible fruit and nuts; citrus fruit or melon peel	C_08
09 Coffee, tea, mate, and spices	C_09
12 Oil seeds, etc.; miscellaneous grain, seed, fruit, plant, etc	C_12
16 Edible preparations of meat, fish, crustaceans, etc	C_16
17 Sugars and sugar confectionary	C_17
19 Prep cereal, flour, starch or milk; bakers wares	C_19
20 Prep vegetables, fruit, nuts or other plant parts	C_20
21 Miscellaneous edible preparations	C_21
22 Beverages, spirits, and vinegar	C_22
23 Food industry residues and waste; prep animal feed	C_23
24 Tobacco and manufactured tobacco substitutes	C_24
28 Inorganic chem; precious and rare earth metals, and radioactive compounds	C_28
29 Organic chemicals	C_29
31 Fertilizers, exports only (including other crude materials)	C_31
32 Tanning and dye ext., etc; dye, paint, putty, etc; inks	C_32
33 Essential oils, etc; perfumery, cosmetic, etc. preps	C_33
34 Soap etc; waxes, polish, etc; candles; dental preps	C_34
35 Albuminoidal substances; modified starch; glue; enzymes	C_35
37 Photographic or cinematographic goods	C_37
38 Miscellaneous chemical products	C_38
39 Plastics and articles thereof	C_39
40 Rubber and articles thereof	C_40
44 Wood and articles of wood; wood charcoal	C_44
48 Paper, paperboard and articles (including paper pulp articles)	C_48
52 Cotton, including yarn and woven fabric thereof	C_52
54 Man-made filaments, including yarns and woven fabrics	C_54
64 Footwear, gaiters, etc., and parts thereof	C_64
69 Ceramic products	C_69
70 Glass and glassware	C_70
72 Cast iron, iron, and steel	C_72
73 Articles of iron and steel, cast iron	C_73
76 Aluminium and articles thereof	C_76
84 Nuclear reactors, boilers, machinery, etc.; parts	C_84
85 Electric machinery, etc; sound equip; tv equip; parts	C_85
87 Vehicles, except railway or tramway, and parts, etc.	C_87
88 Aircraft, spacecraft, and parts thereof	C_88
94 Furniture; bedding, etc.; lamps nos, etc.; prefab bd	C_94

1 month. The ship specification is 1850 TEU operational capacity, 27 000 t of cargo deadweight, 264 plugs for reefer containers, and 550 slots for 40 ft containers.

The planning horizon is 12 periods of 4 weeks, and the necessary statistical data to generate the deterministic demand by cargo type, port of loading, port of discharge, and type of container per period were obtained from the company Dataliner for the year 2004. The demand data have 42 cargo types using the two digits of the Harmonized Commodity Code. Table 4 presents the commodity codes and descriptions as stated in the original demand data.

Table 5 presents the total Brazilian export flow per commodity code and Table 6 presents the total

Table 5 Brazilian exports per commodity codes

Cargo	I_PNG	I_RIG	I_SPB	I_SSZ	I_SUA	Total
C_02	14 294	11 968	0	18 377	0	44 639
C_05	0	0	0	1 210	0	1 210
C_06	0	0	0	1 172	0	1 172
C_08	2 522	11 692	0	23 287	1 268	38 769
C_09	0	0	1 310	31 085	0	32 395
C_12	0	0	0	5 678	0	5 678
C_16	0	625	0	4 277	0	4 902
C_17	0	0	0	1 463	0	1 463
C_20	0	371	0	15 094	920	16 385
C_21	0	536	0	7 288	0	7 824
C_23	0	0	0	1 648	0	1 648
C_24	0	59 032	0	0	0	59 032
C_28	0	0	0	2 739	0	2 739
C_29	0	0	0	1 619	0	1 619
C_33	0	0	0	4 479	0	4 479
C_35	0	0	0	2 086	0	2 086
C_38	275	0	0	1 539	0	1 814
C_39	666	8 750	0	3 782	0	13 198
C_40	766	4 392	736	4 940	0	10 834
C_44	50 480	0	0	2 848	0	53 328
C_48	5 226	0	0	33 672	0	38 898
C_52	1 972	0	0	2 452	0	4 424
C_64	0	2 368	0	0	0	2 368
C_69	859	0	0	0	0	859
C_70	0	0	0	4 356	0	4 356
C_72	0	0	0	2 163	0	2 163
C_73	7 958	0	0	766	0	8 724
C_76	0	0	0	3 030	0	3 030
C_84	6 990	293	0	12 329	0	19 612
C_85	810	0	0	3 458	0	4 268
C_87	3 896	588	0	12 409	0	16 893
C_94	0	14 754	0	1 536	0	16 290
Total	96 714	115 369	2 046	210 782	2 188	427 099

Table 6 European exports per commodity codes

Cargo	I_ANR	I_HAM	I_LEH	I_RTM	I_TIL	Total
C_00	3 718	5 564	1 520	864	0	11 666
C_07	852	0	0	1 636	0	2 488
C_17	660	0	0	0	0	660
C_19	0	0	0	824	0	824
C_20	2 152	0	0	576	0	2 728
C_22	0	0	356	0	0	356
C_23	0	0	0	1 476	0	1 476
C_28	6 814	1 898	0	1 380	652	10 744
C_29	8 736	2 054	376	3 258	502	14 926
C_31	262	468	0	0	0	730
C_32	2 494	772	0	0	0	3 266
C_34	1 298	0	0	0	0	1 298
C_37	640	1 908	0	0	0	2 548
C_38	3 892	1 336	0	0	0	5 228
C_39	18 776	3 700	584	4 422	854	28 336
C_40	4 562	4 144	1 402	3 952	0	14 060
C_44	0	0	0	664	0	664
C_48	25 152	7 436	0	5 496	0	38 084
C_54	520	0	0	0	0	520
C_70	1 106	1 308	0	0	0	2 414
C_72	4 610	1 366	0	984	0	6 960
C_73	484	712	0	0	2 736	3 932
C_76	738	752	0	624	0	2 114
C_84	15 656	11 110	924	844	2 838	31 372
C_85	1 620	2 608	728	580	0	5 536
C_87	65 656	30 706	45 234	2 768	2 776	147 140
C_88	512	0	0	0	0	512
C_94	1 700	0	0	0	0	1 700
Total	172 610	77 842	51 124	30 348	10 358	342 282

European export flow. It is important to note that some commodities appear only in one flow (for example C_02 from Brazil) and that some ports have just a few commodities in their foreign trade (for example SUA with two commodities). Those facts affect the relative importance of the ports and generate trade imbalances in cases where the import and export flows use different container types.

The model considers four different container types in the demand data: 20 ft dry (K20_D), 40 ft dry (K40_D), 20 ft reefer (K20_R), and 40 ft reefer (K40_R). The special containers (open top, flat rack, and platform) are included in the dry container data. For the model application, the available container fleet was assumed to be composed of 7982 units of 20 ft dry, 1876 units of 20 ft reefer, 7922 units of 40 ft dry, and 1761 units of 40 ft reefer containers.

Table 7 presents the total demand per container type and port pairs. The total demand is 769 381 TEU. It can be seen that the 40 ft dry container type represents 73.3 per cent of the total demand and this large percentage may result in a high utilization share of the 40 ft slots in the ships. The market share, weight of full and empty containers, revenues and costs, and operational constraints data are based on real data, making it possible to evaluate the results in relation to the expected behaviour of the liner service industry.

The SADE model was implemented using GAMS (Generalized Algebraic Modelling System) [4] (version Rev 121) and the scenarios were solved using the CPLEX 7.0.0 optimizer. All computational experiments were conducted on a PC with a Pentium 1.6 GHz processor and 1 GB of memory. All scenarios were solved within 2 min of central processing unit (CPU) time. The model statistics for the base scenario (CN00) are: blocks of equations, 14; single equations, 405 817; blocks of variables, 7; single variables, 208 081; non-zero elements, 5 349 433; generation time, 78.515 s; size, 193.3 MB.

4.1 Scenarios

Many scenarios were developed in order to test the model with the commercial conditions that a carrier can be confronted with, as well as with operational conditions that affect its commercial performance, with the aim of analysing the possible alterations to its business plan and consequently to its marketing and sales policy. Several scenarios were explored with the model considering market issues with an operational insight. The following key performance indicators (KPIs) were developed to evaluate the

Table 7 Demand per container type

From	To	K20_D	K20_R	K40_D	K40_R	Total
I_PNG.	J_ANR.	-	-	13 403	942	14 345
	J_HAM.	-	-	8 727	2 025	10 752
	J_LEH.	-	-	8 490	-	8 490
	J_RTM.	737	-	1 627	4 753	7 117
	J_TIL.	397	-	7 135	688	8 220
I_RIG.	J_ANR.	-	-	25 262	288	25 550
	J_HAM.	-	-	4 362	652	5 014
	J_LEH.	-	-	2 548	-	2 548
	J_RTM.	293	371	6 359	8 110	15 133
	J_TIL.	1 213	-	6 385	2 780	10 378
I_SPB.	J_HAM.	976	-	-	-	976
	J_LEH.	-	-	368	-	368
	J_RTM.	334	-	-	-	334
I_SSZ.	J_ANR.	8 364	501	18 563	484	27 912
	J_HAM.	17 927	841	14 878	2 146	35 792
	J_LEH.	1 752	-	1 504	-	3 256
	J_RTM.	11 930	12 988	7 962	17 486	50 366
	J_TIL.	3 877	950	10 651	2 152	17 630
I_SUA.	J_RTM.	-	-	-	1 094	1 094
I_ANR.	J_PNG.	2 008	-	6 752	534	9 294
	J_RIG.	612	-	1 588	-	2 200
	J_SPB.	472	-	1 068	-	1 540
	J_SSZ.	26 066	-	59 608	968	86 642
	J_SUA.	-	-	1 208	-	1 208
I_HAM.	J_PNG.	1 420	-	11 646	-	13 066
	J_RIG.	-	-	516	-	516
	J_SPB.	468	-	-	-	468
	J_SSZ.	10 450	-	19 694	-	30 144
	J_SUA.	-	-	896	-	896
I_LEH.	J_PNG.	544	-	8 838	-	9 382
	J_RIG.	306	-	-	-	306
	J_SPB.	-	-	12 070	-	12 070
	J_SSZ.	1 782	-	3 338	-	5 120
	J_SUA.	-	-	-	-	-
I_RTM.	J_PNG.	-	-	2 338	288	2 626
	J_RIG.	-	-	752	-	752
	J_SPB.	-	-	264	-	264
	J_SSZ.	3 748	-	7 776	818	12 342
	J_SUA.	-	-	1 064	-	1 064
I_TIL.	J_PNG.	658	-	2 394	-	3 052
	J_SSZ.	804	-	2 054	-	2 858
Containers		97 138	15 651	282 088	46 208	441 085
TEU		97 138	15 651	564 176	92 416	769 381
Share (%)		12.6%	2.0%	73.3%	12.0%	100.0%

different scenarios considering the marketing and sales goals and the significant effect of the empty container logistics on the carrier's activities [5].

1. KPIs for scenario evaluations:

- objective function, i.e. the contribution margin;
- total revenue;
- total cost for full containers loading and discharging (full container handling cost);
- total cost for cargo attendance;
- total cost for empty containers loading and discharging (empty container handling cost);
- Total cost for empty container storage.

2. KPIs for marketing and sales:

- share of each cargo type in the contribution margin (import + export);

- (b) market share of the carrier in the total market, i.e. represents its participation percentage in the combined exportations of Brazil and Europe;
- (c) ship capacity utilization in terms of TEUs, cargo deadweight, reefer plugs, and 40 ft containers on board;
- (d) share in the total revenue – it represents the participation percentage of the container type in the carrier total revenue.

3. KPIs for empty container logistics:

- (a) productivity – calculated, per container type, by dividing the number of full containers loaded in the planning horizon by the container fleet;
- (b) repositioning index – calculated, per container type, by dividing the number of empty containers repositioned in the planning horizon by the container fleet;
- (c) storage index – calculated, per container type, by dividing the sum of empty containers that were stored in the planning horizon by the container fleet;
- (d) container fleet utilization index – calculated, per container type, by dividing the container fleet by the available fleet of containers.

Scenarios CN00 to CN09 presented in this paper show the applicability of the model to several commercial and operational conditions normally found in the container liner industry.

Scenario CN00

This scenario is the basis for the comparison with all the other scenarios and it is used to develop the business plan and the portfolio of clients that are the main objectives of this work. Table 9 (in the Appendix) shows the model output summing up all 12 periods in the planning horizon. In order to develop the business plan, the original demand data are searched using each relation <port of loading + port of discharge + commodity code + container type> as the searching key to gather the three most important clients satisfying the searching key. The consolidation of the clients' names found in Table 9 shows 435 active clients that create the carrier's portfolio. The clients' names are presented as stated in the original demand data. Considering that all necessary data to represent the business plan for the liner carrier are presented in Table 9, it can be concluded that the main objective of this work was achieved.

The following data extracted from Table 9 are the basis for an example of the business plan utilization by the sales personnel:

- port of loading, I_SSZ;
- port of discharge, J_ANR;
- commodity code, C_70;
- container type, K40_D;
- containers, 531.0;
- client 1, Saint Gobain Vidros S.A.;
- client 2, Owens Corning Fiberglas;
- client 3, DHL Danzas Air & Ocean.

The sales personnel have to negotiate with the three above clients to secure 531 containers of the 40 ft dry type from Santos to Antwerp with the cargo C_70 during the planning horizon of the business plan with the given freight of \$2600. Table 8 presents the rank of the top 20 clients in terms of commercial importance based on the number of occurrences in Table 9. The top five clients (Kuehne & Nagel, DHL Danzas Air & Ocean, Polytra Nv Transport Engineering, Lexzau Scharbau, and Panalpina) deserve special attention from the sales personnel because they are participating in various commodity flows.

The marketing department is also concerned about the ships utilization level. Table 10 (in the Appendix) presents the model output for the ship's utilization factor per period in terms of cargo deadweight, TEUs, plugs, and 40 ft slots. It is important to mention that the seasonality of the reefer cargoes is reflected in the variation of the plug utilization factor per period. It is also noted that the 40 ft slots can be considered as an operational

Table 8 Client rank for scenario CN00

Rank	Client name	Occurrences
1	KUEHNE & NAGEL	30
2	DHL DANZAS AIR & OCEAN	29
3	POLYTRA NV TRANSPORT ENGINEERING	17
4	LEXZAU SCHARBAU	15
5	PANALPINA	14
6	VOLKSWAGEN GROUP	8
7	VOLKSWAGEN BR LTDA	8
8	VOLKSWAGEN TRANSP GMBH & CO HG	6
9	UTI LOGISTICS	5
10	SADIA SA	5
11	ROHDE & LIESENFELD	5
12	LEHNKERING LOGISTICS	5
13	JAS JET AIR SERVICE FORWARDING	5
14	FISCHER SA AGROINDUSTRIA	5
15	COIMEX COMPANHIA IMP EXP	5
16	BAX GLOBAL LOGISTICS	5
17	TOP SPEED TRADING CO	4
18	TNT LOGISTICS	4
19	SYNGENTA GROUP	4
20	SUCOCITRICO CUTRALE LTDA	4

constraint because the utilization factor is 100 per cent in all periods.

Scenario CN01

This scenario reflects a commercial situation in which the cargo C_02, exported by Brazil, is excluded from the demand, simulating, for example, a foot and mouth disease outbreak that closes foreign markets to Brazilian meat. This cargo represents \$7313772 of the revenue obtained in the basic scenario CN00. This exclusion results in a new cargo selection from the Brazilian and European exports. The new European export flow presents only marginal alterations with respect to scenario CN00. In the Brazilian export flow, the participation of the cargo C_08 increased from 1.66 per cent to 2.76 per cent (+66.3 per cent) in the total revenue. Cargo C_08 has a similar logistics pattern to cargo C_02. It has a seasonal pattern and uses reefer containers (K40_R and K20_R). The KPIs for the scenario evaluation show that although the market share has increased by 0.24 per cent, the contribution margin decreased by 0.35 per cent due to the drop in revenue (−0.13 per cent) and growth in the total costs (+0.73 per cent). The KPIs for empty container logistics present large variations for container types K_20R and K40_R in the repositioning and storage indexes. These variations in the KPIs are explained by the fact that the cargo C_08 was exported only through the ports of Paranaguá and Suape in scenario CN00, but in scenario CN01 it is also exported through the ports of Rio Grande and Santos. With the new port configurations there is a need to increase the repositioning of empty containers and, owing to the seasonality for cargo C_08, there is an increase in the amount of storage of empty containers at those ports. The replacement of cargo C_02 by cargo C_08 demands the development of a new portfolio of clients and the liner carrier should take commercial action to include in this portfolio the new clients in the ports of Rio Grande and Santos and to increase its participation in exports through the port of Suape.

Scenario CN02

This scenario reflects a commercial situation in which cargo C_24 selected in scenario CN00 has its freight rate increased from \$2600 to \$3500 (+34.6 per cent). In this new scenario, there is only a marginal change in the European export flow with respect to scenario CN00, but there is a very large increase in

the Brazilian export flow of cargo C_24, whose participation in the total revenue increased from just 0.36 per cent to 11.0 per cent. Because cargo C_24 is exported only through the port of Rio Grande, the impact on empty container logistics is considerable and the KPIs for empty container logistics show that the cost to attend to the cargo and the repositioning cost increased by 20.20 per cent and 20.87 per cent respectively, but the contribution margin increased by 1.39 per cent.

It is important to notice that, in a liner carrier, the sales and logistics departments are constantly in conflict and have different goals. In this scenario, the increase in the logistic costs can be seen as a negative result for the logistics department. If this department does not have access to the commercial results to prove that the costs increase is justified by the growth in the contribution margin, it will not collaborate with the sales department in carrying out the necessary logistics actions to increase the share of the cargo C_24 in the Brazilian exports.

Scenarios CN03 and CN04

These scenarios reflect operational conditions that affect the return fraction of the empty containers after import discharging (parameter $S_{j,i,k,\delta}^F$ as per Table 2). In scenario CN03 the return rate is changed from (0.0–0.2–0.8) to (0.0–0.4–0.6), in all ports, simulating a decrease in the lead-time related to the process of imported cargoes clearance by the Customs authorities. In scenario CN04, the return fraction is changed from (0.0–0.2–0.8) to (0.0–0.2–0.4–0.4) in the port of Santos only, simulating an increase in lead-time for the imported cargoes clearance.

The change in the return fractions had little influence on the contribution margin, which remained practically stable, with a slight increase of 0.62 per cent in scenario CN03 and a small decrease of 0.04 per cent in the scenario CN04. It is observed in scenario CN03 that with the decrease in the lead-time to clear the imported cargoes there is an increase of the productivity of the container fleet and, consequently, a reduction of the container fleet utilization index. The opposite is observed in scenario CN04, where there is a reduction in the productivity index and a larger fleet utilization index.

Scenario CN05

This scenario reflects an operational situation in which the depth of the port of Santos is reduced by 0.5 m (equivalent to a loss in the cargo deadweight of

4000 t). This scenario simulates a lack of depth maintenance in the access channel or in the container terminals. The reduction in the depth of the port of Santos generates new cargoes selections in the exports from Brazil and Europe, resulting in a market share 0.5 per cent smaller and a contribution margin 3.0 per cent smaller than those obtained in scenario CN00. Although there are only marginal changes in the European export flow with respect to scenario CN00, there are important changes in the relative contribution of the European ports to the total revenue and to TEUs. The port of Le Havre reduced its contribution to the revenue by 6.6 per cent and its contribution to TEUs by 7.0 per cent, but these losses were compensated by the port of Rotterdam, which increased its contribution to the revenue by 2.8 per cent and its contribution to TEUs by 2.9 per cent.

The new cargo selection for Brazilian exports significantly changed the relative contribution of the ports to the total revenue and to the TEUs. The port of Santos lost 6.4 per cent in revenue and 6.6 per cent in TEUs. The port of Paranagua lost 7.8 per cent in revenue and 7.7 per cent in TEUs. These negative variations are partially compensated for by positive variations in the port of Suape, with a growth of 20.2 per cent in revenue and 22.4 per cent in TEUs, and in the port of Rio Grande, with a growth of 19.6 per cent in revenue and 25.9 per cent in TEUs. The port of Sepetiba kept the same contribution as for scenario CN00 because its maximum market share is reached in both scenarios.

The changes in the relative participations of the ports affect the logistics of empty containers, mostly in the positioning of empty containers among the ports. The repositioning of empty containers to Rio Grande increased by 33.4 per cent and to Suape by 18.3 per cent. On the other hand, there was a reduction of 35.9 per cent in the repositioning of empty containers to the port of Santos and of 27.1 per cent to the port of Paranagua. The reduction in the depth of the port of Santos also changes the average utilization of the ships, in the northbound direction, it decreased from 92.7 per cent to 86.3 per cent in cargo deadweight and from 90.3 per cent to 86.3 per cent in TEUs. It is concluded that any reduction in the depth of the port of Santos results not only in revenue loss, but also in a market share loss for the carrier.

Scenario CN06

This scenario reflects a commercial situation in which cargo C₄₈ should be obligatorily included

in the import flow to the port of Suape. This scenario simulates the existence of contract between the liner carrier and its customers that export cargo C₄₈ to Suape. There is an increase of the participation of cargo C₄₈ in the total revenue from 9.38 per cent in scenario CN00 to 14.81 per cent in scenario CN06. Cargo C₄₈ uses container type K40_D, for which there are no export cargoes from the port of Suape, resulting in a higher repositioning of empty containers from that port back to Europe, and reducing the northbound ship capacity for 40 ft full containers.

Scenario CN07

This scenario reflects a commercial situation in which the container imbalance between Brazil and Europe is reduced, by increasing the European exports and keeping the Brazilian exports constant. With this new imbalance pattern, which has a positive effect on the logistics of empty containers, there is an increase of 2.56 per cent in the contribution margin and of 2.60 per cent in the total revenue, mainly due to the growth of the European exports. It is noted that the productivity index for container type K20_D increased due to its high share in the European exports.

Scenarios CN08 and CN09

These scenarios are developed with the aim of determining which actions liner carriers should take to increase their participation in the market (indirectly measured here by the maximum fraction of liner carrier participation in the cargo, P^X) in order to keep its contribution margin constant in case there is a uniform reduction of freight rates. Two cases are analysed: for scenario CN08, there is a 5 per cent reduction in the freight rate with respect to scenario CN00 and for scenario CN09 there is a 10 per cent reduction in the freight rate.

It is important to note that a positive variation of P^X represents an increase in the potential market, in which the model should select the cargoes that maximize the contribution margin. For scenario CN08 it is found, by solving the proposed model for different values of P^X , that with a reduction of 5 per cent in the freight rates, the liner carrier would have the same contribution margin of the basic scenario CN00 with an increase of 7.46 per cent in P^X (changing from 36.13 per cent to 43.59 per cent). A reduction of 10 per cent in the freight rates requires a value of P^X equal to 57.75 per cent. It is also noted that any increase in P^X does not change the carrier's

market share proportionally. In the scenario CN08 the market share increased by 1.01 per cent, while in scenario CN09 it increased by 1.69 per cent. This small change in the market share is explained by the ships' constraints, either in the cargo deadweight or in the TEU capacity.

When the liner carrier is confronted with a market greater than the potential market originally planned, it should restructure its portfolio of clients based on the model results. In cases where the new portfolio is too different from the original portfolio, the carrier should take sales actions with regard to the fact that the current clients may have less or more importance in its new portfolio, some contracts should be renegotiated, and new clients should be acquired.

4.2 Discussion

The analyses developed for scenarios CN00 to CN09 demonstrate the robustness of the model. Its results are revealed to be sufficiently consistent and they represent the reality found in the container liner industry. The development of a portfolio of clients was achieved using the data from the CN00 scenario. The commercial and operational aspects related to the parameters of the model and to the key performance indicators can also be analysed with the model. Examples of these analyses are:

- (a) analyses of each cargo contribution to the liner carrier contribution margin;
- (b) analyses of the liner carrier market share, and the influence of the parameter P^X ;
- (c) analyses of the relative importance of the cargoes and their loading ports;
- (d) analyses and development of a portfolio of clients for a specific cargo type;
- (e) analyses of the ship capacity utilization ratio in TEUs, cargo deadweight, 40 ft containers, and reefer containers;
- (f) analyses of the empty container logistics.

Table 11 (in the Appendix) summarizes the model output for scenarios CN00 to CN09, which were developed with specific objectives; to test and analyse some commercial and operational conditions normally found in the container liner industry. The analyses of the model results reinforce the adherence of the model to the reality of the industry. The development and the application of the KPIs has assisted in the analyses and has allowed the presentation, with sufficient clarity, of some existing cause and effect relationships in the industry. Based

on these analyses it is concluded that the objective of this work has been achieved and that the model has the potential for development to become a support decision system as presented in section 2. The model output also generates enough data to consider the significant influence of empty container logistics in analysis of commercial and operational conditions. The KPIs for empty container logistics for scenarios CN00 to CN09 are summarized in Table 12 (in the Appendix).

5 CONCLUSIONS

The model developed in this work allows the liner carrier to modify its business plan process for the marketing and sales departments, making it more independent of the commercial pressures of each regional office. The analysis of the scenarios, developed with the purpose of verifying the impacts of different commercial or operational conditions, emphasizes the existence of a strong relationship between the logistics of empty containers and the result of the carrier's commercial activity.

It is noticed that any commercial action alters the carrier's logistics situation immediately. The logistics planning should be revised so that the contribution margin is maintained or increased. In the same way, any alteration in the carrier's logistics planning, whether a constraint in the container fleet or a change on its composition, demands commercial action so that the contribution margin is maintained or increased. Generally, the commercial effort for the development of a portfolio of clients demands a lot of time and some of the clients may have service contracts with the carrier, resulting in commercial relationships of medium or long term. This fact decreases the carrier's flexibility to react to the operational changes that demand a new composition of clients in its portfolio in order to keep or increase the contribution margin. In other words, if the model solution indicates the participation of a certain client that is not part of the carrier's current portfolio, the carrier should compete with the others carriers so that it also participates in the selected clients' exports.

The results obtained with the model present a significant adherence to the reality found in the liner industry, indicating that the model can be used in practice with success, since the model efficiently treats the problems faced during the business plan development. The number of scenarios allows a wide range of studies, showing great flexibility for the model application. There-

fore, it is concluded that the main objectives of this work were fully achieved. Although the model has a good adherence to the reality of the liner industry, it does not consider the existence of more than one service calling at the same port. It is generally observed that the excess of containers generated by one service can be used in another one, with the result that the port is balanced from the container logistics point of view. This balanced situation decreases the logistics costs considerably and allows the carrier to develop different portfolios of clients, per service, even if they have imbalances when considered individually. This model is being further developed in order to consider a multi-route pattern.

ACKNOWLEDGEMENTS

This study was undertaken with support from the liner carriers Hamburg Süd and Aliança Navegação e Logística.

REFERENCES

- 1 Institute of Shipping Economics and Logistics, Market analysis 2005 – world merchant fleet, OECD shipping and shipbuilding. *Shipping Statistics Market Rev.*, January/February 2005, 49.
- 2 World Shipping Council, The Ocean Shipping Reform Act of 1998: achieving success, 2001, World Shipping Council, Washington, DC.
- 3 World Shipping Council, Comments of the World Shipping Council to FMC Notice Of Inquiry, Docket No. 01-01, 2001, World Shipping Council, Washington, DC.
- 4 **Brooke, A., Kendrick, D., and Meeraus, A.** *GAMS: a user's guide*, 1988 (The Scientific Press, Redwood City, California).
- 5 **Crainic, C. B. T., Gendreau, M., and Dejax, P.** Dynamic and stochastic models for the allocation of empty containers. *Operations Res.*, 1993, 41(1), 102–126.

APPENDIX

Tables 9–12 (presented in the following pages)

Table 9 Model output for scenario CN00

Port of loading	Commodity code	Commodity type	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
LANR	J_PNG	C_20	K40_R	534	1068	315.0	630.0	1000	IMPEXTRACO NV	GLAREBOUT POTATOES NV IMPEXTRACO NV	NV CLAREBOUT POTATOES SA BASF GROUP
		C_29	K20_D	276	276	92.0	92.0	1000	POLYTRA NV TRANSPORT ENGINEERING LAMITRADE SA	METSO PAPERCHEM OY	KUEHNE & NAGEL
		C_39	K40_D	688	1376	168.0	336.0	1000	TOP SPEED TRADING CO	GRUPPO	ROXCEL HANDELSGES MBH GROUP
		C_40	K40_D	742	1484	38.0	76.0	1000	STORA ENSO	CORDENONS SA	STORA ENSO GROUP
		C_48	K20_D	856	856	167.0	167.0	1500	LANGERBRUGGE NV ROXCEL HANDELSGES	STORA ENSO FORS AB	
		C_48	K40_D	598	1196	74.0	148.0	1500	MBH GROUP	VOLKSWAGEN GROUP	
		C_72	K20_D	342	342	193.0	193.0	1500	ARCELOR GROUP	STORA ENSO FORS AB	ROHDE & LIESENFELD VOLKSWAGEN GROUP
		C_84	K40_D	392	784	163.0	326.0	1500	PERKINO ENGINES CO	HELLMANN	
		C_87	K20_D	534	534	259.0	259.0	1500	TNT LOGISTICS	WORLDWIDE LOGISTICS	
		C_87	K40_D	4332	8664	1695.5	3391.0	2755	VOLVO LOGISTICS AB	VOLVO GROUP	TNT LOGISTICS
J_RIG	C_28	K20_D	292	292	70.0	70.0	1000	POLYTRA NV TRANSPORT ENGINEERING	CHEMISCHE FABRIK BUDENHEIN	CABOT RHEINFELDEN GMBH CO	
	C_29	K20_D	320	320	98.0	98.0	1000	POLYTRA NV TRANSPORT ENGINEERING	CALDIC CHEMIE BV	PERSTORP GROUP	
	C_39	K40_D	424	848	121.0	242.0	1500	BP CHEMICAL INC	BAYER GROUP	DUPONT GROUP	
	C_48	K40_D	314	628	68.0	136.0	1500	UPM KYMMENE CORP	SCHRYVER TRANSPORT LOGISTIC	JOHN DEERE BRASIL SA	
J_SPB	C_84	K40_D	460	920	272.0	544.0	1500	BAX GLOBAL LOGISTICS			
	C_87	K40_D	390	780	236.0	472.0	1500	BAX GLOBAL LOGISTICS			
	C_29	K40_D	422	844	2.0	4.0	1000	DUPONT GROUP	TEXACO GROUP		
J_SSZ	C_76	K20_D	472	472	115.0	115.0	1500	HYDRO ALUMINIUM AS	HYDRO ALUMINIUM DEUTSCHLAND GMBH		
	C_87	K40_D	646	1292	22.5	45.0	1500	PEUGEOT CITROEN GROUP	SCANIA GROUP		
	C_00	K20_D	870	870	200.0	200.0	1000	POLYTRA NV TRANSPORT ENGINEERING	SEACOM DIVISION	DHL DANZAS AIR & OCEAN	
	C_00	K40_D	1424	2848	61.0	122.0	1000	POLYTRA NV TRANSPORT ENGINEERING	SEACOM DIVISION	DHL DANZAS AIR & OCEAN	
	C_07	K40_R	426	852	164.0	328.0	1000	SDV INTERNATIONAL LOGISTICS	KG TRANSPORTE HOLLAND BV	HAMANN GROUP	
	C_17	K40_D	330	660	41.0	82.0	1000	JH BACHMANN GMBH	LESCHACO	JH BACHMANN & CO	
	C_20	K40_R	542	1084	319.0	638.0	1000	VAN DEN BROEKE LUTOSA SA	MC CAIN FOOD CORP	FARM FRITES INTL	
	C_28	K20_D	2274	2274	668.0	668.0	1000	POLYTRA NV TRANSPORT ENGINEERING	POLYTRA	C DASBACH BVBA	
	C_28	K40_D	2124	4248	183.2	366.4	1000	DEGUSSA GROUP	LEXZAU SCHARBAU	CABOT RHEINFELDEN GMBH CO	
	C_29	K20_D	4712	4712	1964.0	1964.0	1000	POLYTRA NV TRANSPORT ENGINEERING	SYNGENTA GROUP	BAYER GROUP	

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Commodity type	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
I_ANR	J_SSZ.	C_29	K40_D	1292	2584	139.3	278.6	1000	1000	POLYTRA NV TRANSPORT ENGINEERING	SYNGENTA GROUP	BAYER GROUP
		C_31	K20_D	262	262	131.0	131.0	1000	1000	POLYTRA NV TRANSPORT ENGINEERING	POLYTRA	BMS MICRO NUTRIETES NV
		C_32	K20_D	842	842	326.0	326.0	1000	1000	POLYTRA NV TRANSPORT ENGINEERING	LEXZAU SCHARBAU	KUEHNE & NAGEL
		C_32	K40_D	826	1652	82.3	164.6	1000	1000	POLYTRA NV TRANSPORT ENGINEERING	LEXZAU SCHARBAU	CLARIANT GROUP
		C_34	K20_D	662	662	254.0	254.0	1000	1000	LEXZAU SCHARBAU	POLYTRA NV TRANSPORT ENGINEERING	UTI LOGISTICS
		C_34	K40_D	318	636	33.0	66.0	1000	1000	LEXZAU SCHARBAU	POLYTRA NV TRANSPORT ENGINEERING	LEVER FABERGE DEUTSCHLAND GMBH
		C_37	K40_D	320	640	46.8	93.6	1000	1000	AGFA GEVAERT GROUP	SCHENKER INTERNATIONAL FORWARDING	DUPONT GROUP
		C_38	K20_D	1268	1268	295.0	295.0	1000	1000	SYNGENTA GROUP	POLYTRA NV TRANSPORT ENGINEERING	LEXZAU SCHARBAU
		C_38	K40_D	1312	2624	40.0	80.0	1500	1500	SYNGENTA GROUP	POLYTRA NV TRANSPORT ENGINEERING	LEXZAU SCHARBAU
		C_39	K20_D	2960	2960	880.0	880.0	1500	1500	POLYTRA NV TRANSPORT ENGINEERING	LTL LOGISTICS	DOW CHEMICAL GROUP
		C_39	K40_D	6482	12964	364.8	729.6	1500	1500	POLYTRA NV TRANSPORT ENGINEERING	BP CHEMICAL INC	LTL LOGISTICS
		C_40	K20_D	302	302	37.0	37.0	1500	1500	RUBBER RESOURCES	LTL LOGISTICS	LLT LOGISTIC GBR
		C_40	K40_D	1388	2776	35.0	70.0	1500	1500	PEGASUS POLYMERS ASIA LTD	MICHELIN GROUP	RUBBER RESOURCES
		C_48	K20_D	4588	4588	1037.0	1037.0	1500	1500	NORSKE SKOG GROUP	STORA ENSO LANGERBRUGGE NV	STORA ENSO
		C_48	K40_D	8356	16712	809.0	1618.0	1500	1500	NORSKE SKOG GROUP	NOSKE SKOG GOLBEY SA	CORBEHEM SA
		C_54	K40_D	260	520	19.0	38.0	1500	1500	INVISTA INTERNATIONAL SA	PANALPINA	DANMAR LINES LTD
		C_70	K20_D	582	582	185.0	185.0	1500	1500	SAINT GOBAIN GROUP	EMGO NV	W NIEMANN
		C_70	K40_D	262	524	24.0	48.0	1500	1500	EMGO NV	GEOLOGISTICS	EUROPEAN OWENS
		C_72	K20_D	3452	3452	1977.0	1977.0	1500	1500	ARCELOR GROUP	PIRELLI GROUP	CORNING FIBERGLASS
		C_72	K40_D	408	816	30.0	60.0	1500	1500	CRONIMET FERROLEGIERUNGEN	ROHLIG LOGISTICS	ARCELOR AUTO
		C_73	K40_D	242	484	9.0	18.0	1500	1500	SAINT GOBAIN GROUP	JAS JET AIR SERVICE FORWARDING	EDELSTAHL WITTEN
		C_76	K20_D	266	266	62.0	62.0	1500	1500	HYDRO ALUMINIUM AS	PANALPINA	KREFELD GMBH
		C_84	K20_D	780	780	467.0	467.0	1500	1500	CATERPILLAR GROUP	ATLAS COPCO GROUP	PANALPINA
		C_84	K40_D	6278	12556	1312.0	2624.0	1500	1500	CATERPILLAR GROUP	ATLAS COPCO GROUP	KUEHNE & NAGEL
		C_85	K40_D	810	1620	113.0	226.0	1500	1500	PHILIPS GROUP	ASB AIR SEA BROKER	UNKNOWN CUSTOMER
		C_87	K20_D	1922	1922	1191.0	1191.0	1500	1500	DAIMLER CHRYSLER GROUP	PANALPINA	PANALPINA
		C_87	K40_D	26232	52464	3192.2	6384.4	1500	1500	SCANIA GROUP	DAIMLER CHRYSLER GROUP	GENERAL MOTORS INT GROUP

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
I_LANR	J_SSZ	C_88	K40_D	256	512	58.0	116.0	1500	DISSACO GSS NV	STRECK TRANSPORT GMBH	
		C_94	K20_D	324	324	186.0	186.0	2259	HAMANN GROUP	HAMANN INTL NV	ASB AIR SEA BROKER
		C_94	K40_D	688	1376	187.0	374.0	2755	HAMANN GROUP	HAMANN INTL NV	HAMANN INTERNATIONAL NV BELGIUM
	J_SUA	C_39	K40_D	314	628	0.0	0.0	1500			
		C_48	K40_D	586	1172	0.0	0.0	1500			
		C_84	K40_D	308	616	0.0	0.0	1500			
I_HAM	J_PNG	C_84	K40_D	396	792	180.0	360.0	1800	ELSPED SPEDITIONSOES GMBH	DHL DANZAS AIR & OCEAN	
		C_85	K40_D	340	680	226.0	452.0	1800	ELSPED SPEDITIONSOES GMBH	GEHR HIRDES GMBH	KARL HEINZ DIETRICH GMBH & CO
		C_87	K20_D	1082	1082	188.0	188.0	1800	VOLKSWAGEN GROUP	VOLKSWAGEN TRANSP GMBH & CO HG	ROHDE & LIESENFELD
		C_87	K40_D	9346	18692	1674.0	3348.0	1800	VOLKSWAGEN GROUP	VOLKSWAGEN TRANSP GMBH & CO HG	ROHDE & LIESENFELD
	J_RIG	C_84	K40_D	516	1032	236.0	472.0	1800	SCHRYVER TRANSPORT LOGISTIC	BAX GLOBAL LOGISTICS	KUEHNE & NAGEL
		C_31	K20_D	468	468	377.0	377.0	1200	KALI & SALZ GMBH	COMPO GMBH & CO	
		C_00	K20_D	1088	1088	384.0	384.0	1200	ROHDE & LIESENFELD	KUEHNE & NAGEL	KD FEDDERSEN & CO
		C_00	K40_D	2238	4476	724.2	1448.4	1200	ROHDE & LIESENFELD	KUEHNE & NAGEL	AC CONTAINER LINE
		C_28	K20_D	914	914	143.0	143.0	1200	EKA CHEMICALS AB	KERR MCGEE	RUSSIAN CHROME CHEMICALS
		C_28	K40_D	492	984	65.0	130.0	1200	EKA CHEMICALS AB	WACKER CHEMIE GMBH	LEXZAU SCHARBAU
		C_29	K20_D	854	854	258.0	258.0	1200	LEXZAU SCHARBAU	CLARIANT GROUP	KD FEDDERSEN & CO
		C_29	K40_D	600	1200	156.0	312.0	1200	LEXZAU SCHARBAU	CLARIANT GROUP	
		C_32	K40_D	386	772	96.0	192.0	1200	LEXZAU SCHARBAU	CLARIANT GROUP	KUEHNE & NAGEL
		C_37	K40_D	954	1908	74.0	148.0	1200	SCHENKER INTERNATIONAL FORWARDING	DANMAR LINES LTD	DHL DANZAS AIR & OCEAN
		C_38	K20_D	392	392	102.0	102.0	1200	LEXZAU SCHARBAU	LTL LOGISTICS	KUEHNE & NAGEL
		C_38	K40_D	472	944	125.0	250.0	1200	LEXZAU SCHARBAU	BAYER GROUP	SCHIRM
		C_39	K20_D	824	824	304.0	304.0	1200	LEXZAU SCHARBAU	WACKER CHEMIE GMBH	KUEHNE & NAGEL
		C_39	K40_D	1438	2876	535.0	1070.0	1200	LEXZAU SCHARBAU	IBEX CONTAINER LINE	WACKER POLYMER SYSTEMS GMBH CO KG
		C_40	K40_D	508	1016	46.0	92.0	1800	CONTINENTAL AGENCIES LTD	BARUM CONTINENTAL SPO	DOW CHEMICAL GROUP
		C_48	K20_D	1078	1078	392.0	392.0	1800	STORA ENSO UETERSEN GMBH & CO KG	STORA ENSO GROUP	UPM KYMMENE CORP
		C_48	K40_D	2400	4800	883.0	1766.0	1800	LAMINATING PAPERS	DANMAR LINES LTD	DHL DANZAS AIR & OCEAN
		C_70	K20_D	268	268	118.0	118.0	1800	BOHEMIA CRYSTALEX TRADING A S	LG PHILIPS DISPLAYS GROUP	SAINT GOBAIN GROUP
		C_70	K40_D	520	1040	233.0	466.0	1800	BOHEMIA CRYSTALEX TRADING A S	IBEX CONTAINER LINE	ITG GMBH INTERNATIONAL FORWARDER

Table 9 Continued.

Port of loading	Commodity code	Commodity type	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
I_HAM	J_SSZ.	C_72	K20_D	474	474	156.0	156.0	1800	HOGANAS AB	EDELSTAHL WITTEN KREFELD GMBH	EKO STAHL GMBH GERMANY
		C_72	K40_D	446	892	149.0	298.0	1800	FAGERSTA STAIMLESS	SAARSTAHL AGENCIA	KUEHNE & NAGEL
		C_73	K40_D	356	712	123.0	246.0	1800	KUEHNE & NAGEL	VOLKSWAGEN GROUP	VOLKSWAGEN TRANSP GMBH & CO HG
		C_76	K20_D	752	752	362.0	362.0	1800	ALCAN DEUTSCHLAND GMBH	ALCAN PACKAGING	ALCAN ALUMINIUM CO GROUP
		C_84	K20_D	1546	1546	722.0	722.0	1800	VOLVO CONSTRUCCION EQUIP N-AMERICA	SCHENKER INTERNATIONAL FORWARDING	KUEHNE & NAGEL
		C_84	K40_D	3584	7168	1686.0	3372.0	1800	VOLVO CONSTRUCCION EQUIP N-AMERICA	VOLVO GROUP	STRECK TRANSPORT GMBH
		C_85	K20_D	268	268	177.0	177.0	1800	ELSPED SPEDITIONSOES GMBH	KUEHNE & NAGEL	GLOBAL TRADING CORP
		C_85	K40_D	830	1660	560.0	1120.0	1800	ELSPED SPEDITIONSOES GMBH	DHL DANZAS AIR & OCEAN	PHILIPS GROUP
		C_87	K20_D	1992	1992	352.0	352.0	1800	VOLKSWAGEN GROUP	VOLKSWAGEN TRANSP GMBH & CO HG	PANALPINA
		C_87	K40_D	4470	8940	796.0	1592.0	1800	VOLKSWAGEN GROUP	VOLKSWAGEN TRANSP GMBH & CO HG	UTI LOGISTICS
J_SUA		C_48	K40_D	610	1220	0.0	0.0	1800			
		C_84	K40_D	286	572	0.0	0.0	1800			
I_LEH	J_PNG	C_00	K40_D	504	1008	71.0	142.0	1100	DHL DANZAS AIR & OCEAN	UTI LOGISTICS	
		C_40	K40_D	332	664	48.0	96.0	1600	TOP SPEED TRADING CO	VITORIA GOMME	UTI LOGISTICS
		C_87	K20_D	544	1088	285.6	571.2	1600	RENAULT GROUP	KUEHNE & NAGEL	UTI LOGISTICS
		C_87	K40_D	8002	16004	1519.2	3038.4	1600	RENAULT GROUP	KUEHNE & NAGEL	UTI LOGISTICS
		C_40	K20_D	306	306	58.0	58.0	1100	LANXESS COPORATION GROUP		
J_SPB		C_87	K40_D	12070	24140	23.0	46.0	1600	MANUFACT FRANCAISE DES PNEUMATIQ	MICHELIN GROUP	
		C_00	K40_D	256	512	23.3	46.6	1100	PANALPINA	GALAX	DHL DANZAS AIR & OCEAN
		C_22	K20_D	356	356	90.0	90.0	1100	DHL DANZAS AIR & OCEAN	GALAX	JF HILLEBRAND GROUP
		C_29	K20_D	376	376	39.0	39.0	1100	PANALPINA	ROQUETE FRERES	ADISSEO FRANCE SAS
		C_39	K40_D	292	584	23.0	46.0	1100	ATOFINA GROUP	RHODIA INTERNATIONAL GROUP	DHL DANZAS AIR & OCEAN
		C_40	K20_D	432	432	78.0	78.0	1600	EXXONMOBIL CORP	DAREX CONTAINER PRODUCTS	EXXONMOBIL CHEMICAL
		C_84	K40_D	462	924	57.0	114.0	1600	SDV INTERNATIONAL LOGISTICS	FILLON	ICL LTD
		C_85	K40_D	364	728	35.0	70.0	1600	SDV INTERNATIONAL LOGISTICS	JAS JET AIR SERVICE FORWARDING	EUROMOTEUR
		C_87	K20_D	618	618	343.0	343.0	1600	JAS JET AIR SERVICE FORWARDING	GEODIS	GETRAG FORD TRANSMISSIOM
		C_87	K40_D	1964	3928	285.4	570.8	1600	JAS JET AIR SERVICE FORWARDING	GEFCO LOGISTICS GROUP	PANALPINA

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
L_PNG	J_ANR.	C_02	K40_R.	942	1884	270.0	540.0	2700	REI DO GADO FAZENDAS LTDA	KING MEAT ALIMENTOS BR LTDA	SADIA SA
		C_44	K40_D.	11590	23180	2677.3	5354.6	2600	FB & M COMERCIO LOG INTL LTDA	SERRARIAS CAMPOS PALMAS SA	DHL DANZAS AIR & OCEAN
		C_48	K40_D.	506	1012	30.0	60.0	2600	KLABIN SA	TETRA PAK LTDA	COAMO
		C_52	K40_D.	642	1284	113.0	226.0	4300	OTAVIANO OLAVO PIVETTA	LINDOLPHO PIO DE CARVALHO DIAS	AGROINDUSTRIAL COOPERATIVA
		C_84	K40_D.	260	520	31.0	62.0	3600	MULTIBRAS SA	GEFCO LOGISTICS GROUP	
		C_85	K40_D.	405	810	77.0	154.0	4200	KUEHNE & NAGEL	WEG EXP SA	FRETTES TRANSITARIO INTL LTDA
J_HAM.		C_02	K40_R.	1741	3482	153.6	307.2	3000	C VALE COOPERATIVA AGROINDUSTRIAL	SADIA SA	DAGRANJA AGROINDUSTRIAL LTDA
		C_08	K40_R.	284	568	38.0	76.0	2700	AGROPEL AGROINDUSTRIAL PERAZZOLI	RENAR MACAS SA	AGROINDUSTRIAL SAO PEDRO VACARIA
		C_40	K40_D.	383	766	62.0	124.0	2600	ECJA COM EXP IMP PROD MANUFAT LTDA	KUEHNE & NAGEL	DHL DANZAS AIR & OCEAN
		C_44	K40_D.	4472	8944	745.4	1490.8	3900	KUEHNE & NAGEL	CEPEVIL CENT PROC ENERG VITORIA	ITAMARATI IND COMPENSADOS
		C_52	K40_D.	344	688	14.0	28.0	3200	COMERCIO E INDUSTRIAS BRAS COINBRA	COTIA TRADING SA	SERVCOM SERVICOS DE COM EXTERIOR
		C_73	K40_D.	1918	3836	208.0	416.0	4200	VOLKSWAGEN BR LTDA		
		C_87	K40_D.	1610	3220	524.0	1048.0	4400	VOLKSWAGEN BR LTDA		
J_LEH.		C_39	K40_D.	333	666	44.0	88.0	3100	EGL EAGLE GLOBAL LOGISTICS	EASYLOG SERV LOG	
		C_44	K40_D.	4895	9790	906.8	1813.6	2700	TIMBER GROUP EXP MAD LTDA	MADEIREIRA BATISTA	PALEDSON IND COM MADEIRAS
		C_48	K40_D.	2107	4214	139.0	278.0	2600	INPACEL IND PAPEL CELULOSE ARAPOTI		
		C_84	K40_D.	817	1634	105.0	210.0	4300	RENAULT BR SA	MULTI EXPORT SUL DESPACHOS LTDA	GEFCO LOGISTICS GROUP
		C_87	K40_D.	338	676	106.0	212.0	3200	RENAULT BR SA	KUEHNE & NAGEL	MULTI EXPORT SUL DESPACHOS LTDA
J_RTM.		C_02	K40_R.	3776	7552	742.6	1485.2	2184	PERDIGAO AGROINDUSTRIAL SA	COOP AGRICOLA CONSOLATA COPACOL	DAGRANJA AGROINDUSTRIAL LTDA
		C_08	K40_R.	977	1954	141.0	282.0	2700	AGROPEL AGROINDUSTRIAL PERAZZOLI	FISCHER FRAIBURG AGRICOLA LTDA	LAURITZENCOOL LOGISTICS
		C_38	K20_D.	275	275	27.0	27.0	2700	RESINAS PARANA IND COMERCIO LTDA	RESINITE IND COM RESINAS	RESIFER COMERCIO E EXPORTACAO LTDA
		C_44	K40_D.	1627	3254	161.0	322.0	4200	COMPENSADOS LFPP LTDA	KUEHNE & NAGEL	COMPENSADOS E LAMINADOS LAVRASUL
		C_69	K20_D.	462	462	114.0	114.0	4400	INCEPA REVESTIMENTOS CERAMICOS	DHL DANZAS AIR & OCEAN	SEA WAY ASSES COML DESP MAR TERR

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
I_PNG	J_TTL	C_02	K40_R	688	1376	115.5	231.0	2284	SADIA SA	COOPERATIVA AGROINDUSTRIAL LAR	PERDIGAO AGROINDUSTRIAL SA
		C_44	K40_D	2656	5312	125.3	250.6	2700	FB & M COMERCIO LOG INTL LTDA	MADEWALKER MADEIRAS LTDA	DHL DANZAS AIR & OCEAN
		C_69	K20_D	397	397	98.0	98.0	3900	INCEPA REVESTIMENTOS CERAMICOS	INCEPA LOUCAS SANTARIAS SA	SCHMIDT IND COM IMP EXP LTDA
		C_73	K40_D	2061	4122	223.0	446.0	4300	DHL DANZAS AIR & OCEAN	CNH LATINO AMERICANA LTDA	BRAZ LOGISTICA INTERNATIONAL LTDA
		C_84	K40_D	2418	4836	325.0	650.0	4200	DHL DANZAS AIR & OCEAN	PRIVATE PERSON	
I_RIG	J_ANR	C_08	K40_R	288	576	0.0	0.0	2600	KUEHNE & NAGEL	FRUITROL AGRIC LTDA	RASIP AGRO PASTORIL SA
		C_24	K40_D	20192	40384	132.3	264.6	3100	UNIVERSAL LEAF TABACOS LTDA	DIMON BR TABACO LTDA	MERIDIONAL TABACOS LTDA
		C_39	K40_D	3058	6116	647.0	1294.0	3000	BRASKEM SA	IPIRANGA	DIJFO BRASIL LTDA
		C_40	K40_D	1192	2384	214.0	428.0	2600	PIRELLI PNEUS SA	PETROQUIMICA SA BRASIL	
		C_94	K40_D	820	1640	63.7	127.4	3700	KUEHNE & NAGEL	TWIN COMPLEXOS LOG LTDA	INTERLOG SOUTH AMERICA LTDA
J_HAM		C_02	K40_R	337	674	10.0	20.0	2600	DOUX FRANGOSUL AGRO AVICOLA IND	COMPANHIA MINUANO ALIM	PENASUL ALIM LTDA
		C_08	K40_R	315	630	0.0	0.0	3300	FRUITROL AGRIC LTDA	AGROINDUSTRIAL LAZZERI LTDA	AGROINDUSTRIAL SAO PEDRO VACARIA
		C_24	K40_D	3786	7572	94.0	188.0	2600	DIMON BR TABACO LTDA	UNIVERSAL LEAF TABACOS LTDA	MERIDIONAL TABACOS LTDA
		C_64	K40_D	270	540	39.0	78.0	4200	TRANSCONTINENTAL LOG SA	ALLINK TRANSPORTES INT LTDA	SCHENKER INTERNATIONAL FORWARDING
		C_94	K40_D	306	612	21.4	42.8	3700	OTM SERVICOS LOG INTL LTDA	EXCEL GLOBAL LOGISTICS INC	FRACHT BR LOG LTDA
J_LEH		C_24	K40_D	1701	3402	0.0	0.0	2600	PIRELLI PNEUS SA	PIRELLI NEUMATICOS ARGENTINA SA	SOCIEDADE MICHELIN PART IND COM
		C_40	K40_D	428	856	73.0	146.0	3000	BAX GLOBAL LOGISTICS	ESLIEL STROPPER ME	SDV INTERNATIONAL LOGISTICS
		C_94	K40_D	419	838	28.9	57.8	2600	DOUX FRANGOSUL AGRO AVICOLA IND	ALIBEM COMERCIAL DE ALIMENTOS LTDA	PENASUL ALIM LTDA
J_RTU		C_02	K40_R	3482	6964	205.7	411.4	2686	TECNOVIN BR LTDA	MONTESUCOS IND ALIM LTDA	
		C_08	K40_R	4628	9256	0.0	0.0	2755	SOLAE BR IND COM ALIM LTDA	PLAST K COM REPR LTDA	GHATS COM EXT LTDA
		C_20	K20_R	371	371	186.0	186.0	3300	DJIFO BRASIL LTDA	BRASKEM SA	
		C_21	K40_D	268	536	93.0	186.0	2600	PIRELLI PNEUS SA	DSM ELASTOMERO BRASIL	
		C_24	K40_D	2519	5038	0.0	0.0	3100	TRANSCONTINENTAL LOG SA	KUEHNE & NAGEL	COMISS ULTRAMAR
		C_39	K40_D	886	1772	130.0	260.0	3000			DESP INTL LTDA
		C_40	K40_D	576	1152	92.0	184.0	3300			
		C_64	K40_D	585	1170	97.0	194.0	2600			

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3	
I_PNG	J_RT.M.	C_84	K20_D.	293	293	70.0	70.0	4200	HYVA BRASIL HIDRAULICA LTDA KUEHNE & NAGEL	ACAWA LOGISTICA GLOBAL LTDA UPS SUPPLY CHAIN SOLUTIONS	GATEWAY CARGO SYSTEMS LTDA THE RUNTIME LOG LTDA	
		C_94	K40_D.	1525	3050	6.2	12.4	3700	DOUX FRANGOSUL AGRO AVICOLA IND	FRIGORIFICO MERCOSUL LTDA	PENASUL ALIM LTDA	
		C_02	K40_R.	2165	4330	26.8	53.6	2592	PAMPEANO ALIMENTOS SA			
	J_TIL.	C_08	K40_R.	615	1230	0.0	0.0	1992	ORDENE SA	BRASKEM SA	SANREMO SA EXPEDITORS	
		C_16	K20_D.	625	625	42.0	42.0	2600	COMISS ULTRAMAR DESP INTL LTDA	CAPITAL CORP	INTERNATIONAL	
		C_24	K40_D.	1318	2636	0.0	0.0	3100	MASTER FREIGHT TRANSPORTES INT	TWIN COMPLEXOS LOG LTDA	JAS JET AIR SERVICE FORWARDING	
		C_39	K40_D.	431	862	54.4	108.8	3100	LAM WESTON	NV CLAREBOUT POTATOES SA		
		C_64	K40_D.	329	658	37.0	74.0	2600	TOP SPEED TRADING CO VOLKSWAGEN TRANSP GMBH & CO HG	COMMERCE USA INC. VOLKSWAGEN GROUP	TOP SEED TRADING CO VOLVO LOGISTICS AB	
		C_87	K20_D.	588	588	53.0	53.0	4200	THYSSENKRUPP STAINLESS EXPORT GMBH	UNKNOWN CUSTOMER	WICKEDER WESTFAHLENSTAHL & CO	
	I_RT.M.	J_PNG.	C_94	K40_D.	4307	8614	0.0	0.0	3700			
			C_20	K40_R.	288	576	47.0	94.0	1600			
	J_SSP.	C_40	C_40	K40_D.	1712	3424	140.0	280.0	1600	TOP SPEED TRADING CO	COMMERCE USA INC.	TOP SEED TRADING CO
C_87			K40_D.	626	1252	205.0	410.0	2755	VOLKSWAGEN TRANSP GMBH & CO HG	VOLKSWAGEN GROUP	VOLVO LOGISTICS AB	
J_SZ.		C_00	C_72	K40_D.	492	984	60.0	120.0	1600	THYSSENKRUPP STAINLESS EXPORT GMBH	UNKNOWN CUSTOMER	WICKEDER WESTFAHLENSTAHL & CO
			C_87	K40_D.	260	520	101.0	202.0	1600	BAX GLOBAL LOGISTICS	PAGUAG GMBH & CO	HELLMANN
			C_40	K40_D.	264	528	14.0	28.0	1600	ASIAN TIRE WHOLESALERS INC	TURBOSTAR BEAUCLAIR	WORLDWIDE LOGISTICS
J_SZ.		C_00	C_00	K20_D.	276	276	41.0	41.0	920	LEHNERING LOGISTICS	DAMEN SHIPYARDS	DHL DANZAS AIR & OCEAN
			C_00	K40_D.	294	588	43.0	86.0	920	LEHNERING LOGISTICS	DAMEN SHIPYARDS	DHL DANZAS AIR & OCEAN
			C_07	K40_R.	818	1636	179.0	358.0	920	JP BEEMSTERBOER BV	KG TRANSPORTE HOLLAND BV	GOURMET BV
J_SZ.		C_19	C_19	K40_D.	412	824	24.0	48.0	920	GEODIS		CABOT TRADING CO LTD
			C_23	K40_D.	738	1476	61.0	122.0	920	SLOTEN BV		LTD
			C_28	K20_D.	636	636	139.0	139.0	1600	LEHNERING LOGISTICS	ALMATHIS BV	CS CABOT SPOL SRO
J_SZ.		C_28	C_28	K40_D.	372	744	64.0	128.0	1600	CABOT TRADING CO LTD	INEOS CHEMICALS GROUP	CS CABOT SPOL SRO
	C_29		K20_D.	1698	1698	312.0	312.0	1600	AKZO NOBEL GROUP	PERSTORP GROUP	LEHNERING LOGISTICS	
	C_29		K40_D.	780	1560	125.0	250.0	1600	DSM NUTRITIONAL PRODUCTS INC	DSM SPECIAL PRODUCTS BV	ROCHE VITAMINS GROUP	
J_SZ.	C_39	C_39	K20_D.	822	822	125.0	125.0	1600	LEHNERING LOGISTICS	INVISTA NEDERLAND BV	AKZO NOBEL GROUP	
		C_39	K40_D.	1800	3600	268.0	536.0	1600	GENERAL ELECTRIC PLASTICS BV	GENERAL ELECTRIC	EASTMAN CHEMICAL GROUP	
		C_44	K40_D.	332	664	92.0	184.0	1600	KIKI JUICES BV	VERBRUGGEN JUICE TRADING BV	VERBRUGGEN JUICE TRADING	
J_SZ.	C_48	C_48	K20_D.	316	316	117.0	117.0	1600	ELOF HANSSON AB	STORA ENSO CORBEHEM SA	SAPPI PAPIER HOLDING GMBH	

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
I_RTM	J_SZ.	C_48	K40_D.	1526	3052	580.2	1160.4	1600	NORSKE SKOG GROUP	BROCKMOOR TRADING LTD	KAPPA GRAPHIC BOARD BV
		C_76	K40_D.	312	624	28.0	56.0	1600	REXAM BEVERAGE	DHL DANZAS AIR & OCEAN	REXAM BEV CAN RECKLINGHAUSE GMBH
		C_84	K40_D.	422	844	130.0	260.0	1600	DHL DANZAS AIR & OCEAN	PHILIPS GROUP	CORUS UK LTD
		C_85	K40_D.	290	580	181.0	362.0	1600	PHILIPS GROUP	ABX INTERNATIONAL LOGISTICS	ENTEK INTERNATIONAL LTD
		C_87	K40_D.	498	996	175.0	350.0	2259	EGL EAGLE GLOBAL LOGISTICS	DAIMLER CHRYSLER GROUP	PANALPINA
	J_SUA.	C_48	K40_D.	1064	2128	0.0	0.0	1600	SENDAS COM EXT SA	TRISTAO COMPANHIA DE COM EXTERIOR	COIMEX COMPANHIA IMP EXP
I_SPB	J_HAM.	C_09	K20_D.	976	976	732.0	732.0	1912	SOCIEDADE MICHELIN PART IND COM	NITRIFLEX SA IND COM	COIMEX COMPANHIA IMP EXP
	J_LEH.	C_40	K40_D.	368	736	74.0	148.0	3000	TRISTAO COMPANHIA DE COM EXTERIOR	EXP CAFE GUAXUPE	COIMEX COMPANHIA IMP EXP
	J_RTM.	C_09	K20_D.	334	334	249.0	249.0	1912	COOP REG CAFEICULT GUAXUPE COOXUPE	COIMEX COMPANHIA IMP EXP	UNICAFE COMPANHIA COM EXTERIOR
I_SSZ	J_ANR	C_09	K20_D	5803	5803	2955.0	2955.0	1912	COOP REG CAFEICULT GUAXUPE COOXUPE	COIMEX COMPANHIA IMP EXP	UNICAFE COMPANHIA COM EXTERIOR
		C_09	K40_D	272	544	134.0	268.0	2451	COOP REG CAFEICULT GUAXUPE COOXUPE	COIMEX COMPANHIA IMP EXP	UNICAFE COMPANHIA COM EXTERIOR
		C_17	K20_D	335	335	58.0	58.0	2184	FBA FRANCO BRAS SA ACUCAR ALCOOL	COMPANHIA ALBERTINA MERCANTIL IND	NARDINI AGROINDUSTRIAL LTDA
		C_20	K20_R	501	501	464.0	464.0	2434	CARGILL AGRICOLA SA	FISCHER SA	AGROINDUSTRIAL LTDA
		C_20	K40_R	484	968	449.0	898.0	2686	CARGILL AGRICOLA SA	FISCHER SA	COINBRA FRUTESP SA
		C_21	K40_D	313	626	125.0	250.0	1992	COMPANHIA IGUACU DE CAFE SOLUVEL	ALFA LAT INDUSTRIAL LTDA	NOVA LOG INTL
		C_28	K20_D	427	427	236.0	236.0	2755	ELFUSA GERAL ELETROFUSAO	TREIBACHER SCHLEIFMITTEL BR LTDA	FREEWAY INTL LOG LTDA
		C_28	K40_D	521	1042	292.0	584.0	3100	BAYER SA	LANXESS IND QUIMICOS E PLASTICOS	ELFUSA GERAL ELETROFUSAO
		C_29	K40_D	491	982	106.0	212.0	3300	DPL CONQUEST BR LTDA	NIVER LOG SA	BASF SA
		C_33	K40_D	582	1164	359.0	718.0	3500	FIORDE ASSES DESP LTDA	FISCHER SA	BASF SA
		C_38	K40_D	623	1246	99.0	198.0	3500	MONSANTO BRASIL LTDA	AGROINDUSTRIA BASF SA	PHIBRO SAUDE ANIMAL INTL LTDA
		C_39	K40_D	554	1108	231.0	462.0	3500	COMPANHIA NITRO QUIMICA BRASILEIRA	SOLUTIA BR LTDA	RHODIA POLIAMIDA BRASIL LTDA
		C_40	K40_D	645	1290	117.0	234.0	3500	GOODYEAR BR PROD BORRACHA LTDA	CLC COM INTL LTDA	CATERPILLAR BRASIL LTDA
		C_44	K40_D	747	1494	319.0	638.0	3050	EUCATEX SA IND COM	PLY IND	KUEHNE & NAGEL
		C_48	K40_D	7707	15414	1114.7	2229.4	3000	VCP EXP PART SA	COMPENSADOS LTDA COMPANHIA SUZANO PAPEL CELULOSE	RIPASA SA CELULOSE PAPEL

Table 9 Continued.

Port of loading	Commodity code	Commodity type	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
L_SSZ	J_ANR	C_52	K40_D	690	1380	179.0	358.0	2700	COMERCIO E INDUSTRIAS BRAS COINBRA	ESTEVE SA	BUNGE ALIMENTOS SA
		C_70	K40_D	2178	4356	531.0	1062.0	2600	SAINT GOBAIN VIDROS SA	OWENS CORNING FIBERGLAS A S LTDA	DHL DANZAS AIR & OCEAN
		C_72	K20_D	433	433	119.0	119.0	2600	BELGO BEKAERT ARAMES SA	CATALISE IND E COMERCIO DE METAIS	PANALPINA
		C_84	K20_D	640	640	310.0	310.0	3800	DAIMLER CHRYSLER DO BRASIL LTDA	DHL DANZAS AIR & OCEAN	KUEHNE & NAGEL
		C_84	K40_D	829	1658	408.0	816.0	4300	DAIMLER CHRYSLER DO BRASIL LTDA	DHL DANZAS AIR & OCEAN	BSH CONTINENTAL ELETRODOMEST LTDA
		C_87	K20_D	726	726	246.0	246.0	3200	PANALPINA	DAIMLER CHRYSLER DO BRASIL LTDA	
		C_87	K40_D	1947	3894	673.0	1346.0	2600	PANALPINA	DAIMLER CHRYSLER DO BRASIL LTDA	DPL CONQUEST BR LTDA
		C_94	K40_D	464	928	128.0	256.0	4500	PANALPINA	INTERLOG SOUTH AMERICA LTDA	
J_HAM		C_02	K20_R	841	841	0.0	0.0	1999	SADIA SA	FRIBOI LTDA	INDEPENDENCIA ALIMENTOS LTDA
		C_02	K40_R	1526	3052	43.2	86.4	1912		BERTIN LTDA	SEARA ALIMENTOS SA
		C_05	K20_D	602	602	324.0	324.0	2451	IND SUBPROD ORIG ANIMAL LOPESCOV		
		C_05	K40_R	304	608	0.0	0.0	2184			
		C_08	K40_R	316	632	0.0	0.0	2686			
		C_09	K20_D	15165	15165	7712.0	7712.0	1992	STOCKLER COM EXPORTACAO DE CAFE	MARCELLINO MARTINS E JOHNSTON EXP	COSTA CAFE COM EXP IMP LTDA
		C_09	K40_D	1623	3246	822.0	1644.0	2592	FUCHS AGRO SCIENCE BRASIL		
		C_17	K20_D	308	308	53.0	53.0	3100	USINAS ITAMARATI SA	NATIVE PROD ORGANICOS COML IMP LTDA	COPERSUGAR COOP ACUCAR ALCOOL SP
		C_21	K40_D	2098	4196	870.0	1740.0	3300	COMPANHIA CACIQUE CAFE SOLUVEL	ICC INDL COM EXP IMP	COMPANHIA IGUACU DE CAFE SOLUVEL
		C_23	K40_D	540	1080	100.0	200.0	3300	SUCOS KIKI LTDA	CP KELCO BRASIL SA	
		C_29	K20_D	367	367	77.0	77.0	3500	CARAMURU ALIM LTDA	BASF SA	AJINOMOTO BIOLATINA E COMERCIO
		C_33	K40_D	741	1482	461.0	922.0	3300	COLGATE PALMOLIVE IND E COM LTDA	DHL DANZAS AIR & OCEAN	NOVA LOG INTL
		C_35	K40_D	646	1292	350.0	700.0	3050	GELITA BR LTDA	REBIERE GELATINAS PRES EPTACIO LTDA	
		C_39	K40_D	506	1012	208.0	416.0	2700	PLASTIPAK PACKAGING BR LTDA	VOLKSWAGEN BR LTDA	
		C_44	K40_D	677	1354	271.8	543.6	2600	VOLKSWAGEN BR LTDA	CARIBEIA INDUSTRIA MADEIREIRA LTDA	KODAK BRAS COM IND LTDA
		C_52	K40_D	536	1072	45.0	90.0	3900	COMERCIO E INDUSTRIAS BRAS COINBRA	VICUNHA TEXTIL SA	CONACENTRO COOP PROD CENTRO OESTE
		C_73	K40_D	383	766	262.0	524.0	4300	VOLKSWAGEN BR LTDA	VOLVO BR VEICULOS LTDA	BSH CONTINENTAL ELETRODOMEST LTDA
		C_84	K20_D	1075	1075	527.0	527.0	3650	MAHLE METAL LEVE SA	THYSSENKRUPP METAL CAMPO LIMPO	TECUMSEH BR LTDA

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
L_SSZ	J_HAM	C_84	K40_D	3076	6152	1523.0	3046.0	3200	BSH CONTINENTAL ELETRODOMEST LTDA	VOGEL TRANSP AGENC CARGA INTL	VOITH PAPER MAQ EQUIP LTDA
		C_85	K40_D	1334	2668	562.0	1124.0	4200	ENERTEC BR LTDA	EXCEL GLOBAL LOGISTICS INC	PHILIPS BRASIL LTDA
		C_87	K20_D	410	410	136.0	136.0	3200	VOLKSWAGEN BR LTDA	DHL DANZAS AIR & OCEAN	CONTINENTAL BR PROD AUTOMOTIVOS
		C_87	K40_D	2718	5436	943.0	1886.0	3700	VOLKSWAGEN BR LTDA	MAGNETI MARELLI COFAP AUTOPECAS SA LTDA	VOLVO BR VEICULOS
J_LEH		C_09	K20_D	1752	1752	889.0	889.0	1912	STOCKLER COM EXPORTACAO DE CAFE	COOP REG CAFEICULT GUAXUPE COOXUPE IMP EXP	COIMEX COMPANHIA
		C_09	K40_D	459	918	228.0	456.0	3100	NOSSA SRA GUIA EXP CAFE LTDA	SUMATRA CAFES BR SA	COM IND BRANCO PERES DE CAFE LTDA
		C_21	K40_D	316	632	127.0	254.0	3300	ACUCAREIRA ZILLO LORENZETTI	PRODESA PROD ESPEC ALIMENTOS SA	ICC INDL COM EXP IMP
		C_48	K40_D	729	1458	124.0	248.0	2600	LOGITEC LOG IMP LTDA	INTERNATIONAL PAPER DO BRASIL LTDA	KUEHNE & NAGEL
J_RTM		C_02	K20_R	2398	2398	86.0	86.0	1912	FRIBOI LTDA	MARFRIG LTDA	SATEL DESPACHOS SERICOS ADUA TECNIC
		C_02	K40_R	4158	8316	120.9	241.8	1877	FRIBOI LTDA	SADIA SA	MARFRIG LTDA
		C_06	K40_R	586	1172	0.0	0.0	2451			
		C_08	K20_R	733	733	0.0	0.0	2755			
	C_08	K40_R	10219	20438	0.0	0.0	2184				
	C_09	K20_D	3139	3139	1597.0	1597.0	2184	STOCKLER COM EXPORTACAO DE CAFE	EXP CAFE GUAXUPE	UNICAFE COMPANHIA COM EXTERIOR	
	C_12	K20_D	478	478	56.0	56.0	2184	YOKI ALIMENTOS SA	SEMENTES ESPERANCA COM IMP EXP	POMPEIA SA IND COM	
	C_12	K40_D	1927	3854	239.3	478.6	2184	YOKI ALIMENTOS SA	COOP PLANT DE CANA ZONA GUARIBA	CAP AGROPEC INDL LTDA	
	C_16	K40_R	814	1628	0.0	0.0	2434				
	C_17	K20_D	820	820	152.0	152.0	2434	GOJASA GOIATUBA ALCOOL LTDA	TSL TRANSP SOLUCOES LOG	NATIVE PROD ORGANICOS COML IMP LTDA	
	C_20	K20_D	350	350	321.0	321.0	2686	DULCINI SA	SUCOCITRICO CUTRALE LTDA	N & N POLPAS FRUTAS LTDA	
	C_20	K20_R	9857	9857	7275.5	7275.5	1992	SUCOCITRICO CUTRALE LTDA	SUCOS KIKI LTDA	BASCITRUS AGROINDUSTRIA SA	
	C_20	K40_R	1709	3418	1597.0	3194.0	2592	SUCOCITRICO CUTRALE LTDA	FISCHER SA AGROINDUSTRIA	SUCORRICO SA	
	C_23	K40_D	284	568	50.0	100.0	2259	SUCOS KIKI LTDA	METACHEM INDL COML	CP KELCO BRASIL SA	
	C_28	K20_D	576	576	323.0	323.0	2755	FERMAVI ELETROQUIMICA LTDA	DIJFO BRASIL LTDA	TREIBACHER SCHLEIFMITTEL BR LTDA	
	C_28	K40_D	347	694	192.0	384.0	3050	DEGUSSA BRASIL LTDA	AJINOMOTO	CARGILL AGRICOLA SA	
	C_29	K20_D	270	270	57.0	57.0	3300	AJINOMOTO BIOLATINA E COMERCIO	INTERAMERICANA INDL COM		
	C_33	K20_D	940	940	584.0	584.0	3500	CTS BR CONSOLIDACAO TRANS SERV	COINBRA FRUTESP SA	FISCHER SA AGROINDUSTRIA	

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
L_SSZ	J_RTU	C_33	K40_D	282	564	170.0	340.0	3500	GTS BR CONSOLIDACAO TRANS SERV	COLGATE PALMOLIVE IND E COM LTDA	
		C_38	K20_D	293	293	44.0	44.0	3050	RESINAS TROPICAIS IND COM LTDA	RESINAS BRASIL IND COM	SOCER BR IND COM LTDA
		C_39	K40_D	831	1662	346.0	692.0	3000	3M BRASIL LTDA	SCHOLLE LTDA	TSL TRANSP SOLUCOES LOG
		C_40	K40_D	1561	3122	292.0	584.0	3900	BRIDGESTONE FIRESTONE BRASIL IND COM	KRATON POLYMERS BR SA	CLC COM INTL LTDA
		C_72	K20_D	948	948	269.0	269.0	4300	CODEMIN SA	VILLARES METALS SA	ANGLO AMERICAN SOUTH AMERICA LTDA
		C_72	K40_D	391	782	108.0	216.0	3650	GRONIMET BRASIL LTDA	BR LOGISTICS TRANSITARIO CARGAS INT	INTERPORT LOG LTDA
		C_76	K20_D	3030	3030	669.0	669.0	3200	COMPANHIA BRASILEIRA ALUMINIO CBA	ALCOA ALUMINIO SA	FERTIMPOR SA
		C_84	K20_D	751	751	365.0	365.0	2600	KUEHNE & NAGEL	FIORDE ASSES DESP LTDA	THYSSENKRUPP METAL CAMPO LIMPO
		C_84	K40_D	836	1672	411.0	822.0	4200	GENERAL MOTORS DO BRASIL LTDA	VOLVO BR VEICULOS LTDA	BACHMANN ECOTRANS
		C_85	K40_D	395	790	164.0	328.0	3700	PHILIPS BRASIL LTDA	DHL DANZAS AIR & OCEAN	ROBERT BOSCH LTDA
		C_87	K20_D	335	335	111.0	111.0	3700	KUEHNE & NAGEL	ACOTECNICA SA IND COMERCIO	SCHAEFFLER BR LTDA
		C_87	K40_D	804	1608	276.0	552.0	4200	SCANIA LATIN AMERICA LTDA	DHL DANZAS AIR & OCEAN	ATRADE CARGO BRASIL LTDA
		C_94	K40_D	304	608	79.0	158.0	4500	UPS SUPPLY CHAIN SOLUTIONS	SKYLINE EXPRESS INTL BR LTDA	MAERSK LOGISTICS
	J_TIL	C_02	K20_R	950	950	0.0	0.0	1912			
		C_02	K40_R	1410	2820	0.0	0.0	2592			
		C_08	K40_R	742	1484	0.0	0.0	2184			
		C_09	K20_D	518	518	219.2	219.2	2686	MARCELLINO MARTINS E JOHNSTON EXP	SUMATRA CAFES BR SA	COOP REG CAFEICULT GUAXUPE COOXUPE
		C_12	K40_D	673	1346	82.0	164.0	2592	YOKI ALIMENTOS SA	COOP PLANT DE CANA ZONA GUARIBA	CAP AGROPEC INDL LTDA
		C_16	K20_D	2649	2649	1101.0	1101.0	3050	BERTIN LTDA	FRIBOI LTDA	BF PROD ALIMET LTDA
		C_21	K40_D	917	1834	377.0	754.0	3300	COMPANHIA CACIQUE CAFE SOLUVEL	NESTLE BRASIL LTDA	ICC INDL COM EXP IMP
		C_33	K20_D	329	329	201.0	201.0	3300	SUCOCITRICO CUTRALE LTDA	MONTECITRUS TRADING SA	BARCI & COMPANHIA
		C_35	K40_D	397	794	212.0	424.0	3000	GELITA BR LTDA	REBIERE GELATINAS	REBIERE GELATINAS LTDA
		C_40	K40_D	264	528	46.0	92.0	2600	PIRELLI PNEUS SA	GOODYEAR BR PROD	VOLKSWAGEN BR LTDA
		C_48	K40_D	8400	16800	174.5	349.0	4200	VCP EXP PART SA	BORRACHA LTDA	RIPASA SA CELULOSE PAPEL
		C_84	K20_D	381	381	182.0	182.0	3700	KS PISTOES	KUEHNE & NAGEL	TECUMSEH BR LTDA

Table 9 Continued.

Port of loading	Port of discharge	Commodity code	Container type	Demand containers	Demand TEU	Model output containers	Model output TEU	Freight (\$)	Client list 1	Client list 2	Client list 3
I_SUA	J_RT.M.	C_08	K40_R.	634	1268	426.0	852.0	4500	AGRICOLA SAO FRANCISCO LTDA	COPA FRUIT IMP EXP LTDA	SECCHI AGRICOLA IMP EXP LTDA
		C_20	K40_R.	460	920	421.0	842.0	5500	INTRAFRUT IND TRANSFORM DE FRUTOS	EXOTIC JUICES	
I_TIL	J_PNG.	C_73	K40_D.	1368	2736	111.0	222.0	1400	DHL DANZAS AIR & OCEAN		
		C_84	K20_D.	658	658	130.0	130.0	2600	TNT LOGISTICS	PERKINO ENGINES CO	EGL EAGLE GLOBAL LOGISTICS
		C_84	K40_D.	504	1008	98.0	196.0	2600	PERKINO ENGINES CO		DHL DANZAS AIR & OCEAN
		C_87	K40_D.	522	1044	51.0	102.0	2600	TNT LOGISTICS	DENSO MARSTON LTD	RENAULT GROUP
	J_SSZ.	C_28	K40_D.	326	652	181.0	362.0	1400	CABOT CARBON LTD	INEOS CHEMICALS GROUP	MILENIUM INORGANIC CHEMICALS SA
		C_29	K20_D.	502	502	221.0	221.0	1400	INEOS CHEMICALS GROUP	COGNIS GROUP	SOLUTIA INC
		C_39	K20_D.	302	302	66.0	66.0	2600	CIBA SPECIALTY CHEMICALS GROUP	MARLEY FLOORS & WATERPROOFING	COGNIS GROUP
		C_39	K40_D.	276	552	60.0	120.0	2600	CIBA SPECIALTY CHEMICALS GROUP	RESOLUTION EUROPE	ROHM & HASS GROUP
		C_84	K40_D.	586	1172	116.0	232.0	2600	NNR OCEAN	NNR GLOBAL LOG USA INC	KOMATSU GROUP
		C_87	K40_D.	866	1732	90.0	180.0	2600	LAND ROVER EXPORTS LTD	LAND ROVER GROUP LTD	TOYOTA MOTOR CORP GROUP
Total				441085	769381	99017.5	151691.7				
Market Share (%)					22.45	19.72					

Table 10 Ships utilization for scenario CN00

Period	T_01	T_02	T_03	T_04	T_05	T_06	T_07	T_08	T_09	T_10	T_11	T_12	Average
Plug	4.25	5.32	3.46	9.04	9.13	5.41	5.32	4.08	14.00	12.14	10.90	7.71	7.6
NB total	99.11	99.73	100.00	100.00	94.45	90.08	89.19	73.94	80.52	77.42	83.96	68.57	88.1
SB total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
NB total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TEU	92.8	90.7	89.6	88.4	92.2	88.9	86.7	85.9	99.7	88.2	92.1	89.9	90.4
NB total	87.1	88.0	90.1	90.3	92.2	92.7	87.6	85.5	90.5	94.6	90.6	95.1	90.3
SB full	67.1	65.5	67.9	65.8	70.8	70.4	67.4	71.3	79.2	72.5	69.7	68.1	69.6
NB full	87.1	88.0	90.1	90.3	92.2	92.7	87.6	85.5	90.5	94.4	90.6	95.1	90.3
SB empty	25.7	25.2	21.7	22.7	21.4	18.4	19.3	14.6	20.5	15.7	22.4	21.9	20.8
NB empty	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
SB total	59.6	60.2	60.5	61.3	65.0	64.0	62.1	61.2	73.9	68.3	66.6	60.3	63.6
NB total	92.7	92.4	96.7	95.9	97.7	98.8	90.4	83.9	91.9	96.1	90.5	96.3	93.6
SB full	56.1	56.7	57.5	58.1	62.0	61.5	59.5	59.2	71.1	66.2	63.5	57.3	60.7
NB full	92.7	92.4	96.7	95.9	97.7	98.8	90.4	83.9	91.9	96.1	90.5	96.3	93.6
SB empty	3.5	3.5	3.0	3.1	2.9	2.5	2.7	2.0	2.8	2.1	3.1	3.0	2.8
NB empty	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 11 KPIs for scenarios CN00 to CN09

Scenario	Scenarios evaluation KPI			Cost item				Market share (%)
	Contribution margin (\$)	Revenue (\$)	Total cost (\$)	Full container handling cost (\$)	Cost to attend the cargo (\$)	Empty container handling cost (\$)	Empty container storage cost (\$)	
CN00	176 368 143	222 660 305	46 292 160	37 572 995	1 207 110	6 791 966	720 089	19.72
CN01	175 748 166	222 379 654	46 631 487	37 904 970	1 108 147	6 828 995	789 375	19.96
CN02	178 817 430	226 431 085	47 613 656	37 254 828	1 450 982	8 209 662	698 184	19.75
CN03	177 457 725	224 220 620	46 762 895	37 970 339	1 188 181	6 880 416	723 959	19.90
CN04	176 299 734	222 582 830	46 283 096	37 476 992	1 237 309	6 856 808	711 987	19.65
CN05	171 074 644	215 012 266	43 937 622	36 020 375	1 131 774	5 947 215	838 258	19.22
CN06	174 635 293	220 921 537	46 286 244	37 386 975	1 201 687	6 909 520	788 062	19.55
CN07	180 856 290	228 449 382	47 593 091	39 221 379	1 235 128	6 431 764	704 820	18.32
CN08	176 308 411	224 761 463	48 453 051	40 048 005	1 213 999	6 617 829	573 218	20.72
CN09	176 376 403	225 088 186	48 711 784	41 530 960	1 172 122	5 663 984	344 718	21.41

Table 12 Empty container logistics KPIs for scenarios CN00 to CN09

Container type	Index	CN00	CN01	CN02	CN03	CN04	CN05	CN06	CN07	CN08	CN09
K20_D	Revenue share (%)	27.9	28.0	27.5	27.7	27.9	25.5	28.3	29.2	30.3	31.3
	Container productivity	5.25	5.23	5.25	5.81	4.88	5.29	5.19	5.36	5.56	5.88
	Container repositioning (%)	32.6	32.8	32.6	32.7	32.6	25.2	32.9	27.2	29.8	23.8
K20_R	Container storage (%)	15.8	16.7	15.9	14.1	17.8	21.6	18.2	16.5	6.2	0.4
	Container fleet utilization (%)	91.4	92.0	91.5	82.7	98.4	81.5	92.8	99.4	100.0	100.0
	Revenue share (%)	9.9	9.9	9.8	10.6	9.9	10.2	10.0	9.6	9.3	8.9
K40_D	Container productivity	4.27	4.26	4.28	4.60	4.27	4.28	4.28	4.27	4.24	4.29
	Container repositioning (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Container storage (%)	1.0	1.4	0.6	0.7	1.0	0.5	0.3	1.1	2.7	0.0
K40_R	Container fleet utilization (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Revenue share (%)	51.4	53.1	52.4	51.8	50.9	53.3	51.0	50.4	51.3	52.5
	Container productivity	6.18	6.15	5.95	6.78	5.85	6.17	6.13	6.29	6.16	6.33
K40_R	Container repositioning (%)	4.9	5.6	14.0	5.2	4.9	6.3	5.5	4.5	4.1	2.5
	Container storage (%)	9.4	9.6	7.8	11.7	6.6	8.2	10.3	6.3	10.5	7.0
	Container fleet utilization (%)	95.8	100.0	100.0	88.7	100.0	96.1	95.2	94.1	98.8	100.0
K40_R	Revenue share (%)	10.8	9.0	10.3	10.0	11.3	11.0	10.7	10.8	9.1	7.4
	Container productivity	3.80	3.47	3.74	4.15	3.68	3.50	3.77	3.86	3.96	4.08
	Container repositioning (%)	68.7	71.8	67.2	65.2	70.8	68.1	68.8	64.3	58.9	45.8
K40_R	Container storage (%)	67.0	93.7	73.4	64.0	70.6	95.0	69.8	66.2	64.3	68.4
	Container fleet utilization (%)	86.4	79.8	86.1	73.8	93.2	92.8	86.4	88.7	75.9	65.5