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Strategic Pricing in Newly Privatised Ports

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Following privatisation, ports face an immediate need to set their prices. For this, they should assess their strategic environment, including: (a) the complex, network-like structure of their port system consisting of principal and intermediary parties; (b) the flow of services and related charges among the above-mentioned parties; (c) the differentiation and price discrimination in the market for port services; (d) the high concentration on both the demand and supply sides of this market; and (e) the mixture of competitive and cooperative behaviours among market agents. The methodology for price setting presented in this paper is based on a systematic assessment of the strategic environment. The methodology employs two novel diagnostic tools: a charge-flow diagram for analysing the allocation of port charges among principal and intermediate parties, and a game tree for analysing the port/competitors, action/reaction dynamics of the oligopolistic market. The methodology is discussed and illustrated using the case of the Port of Cartagena, Colombia.

Keywords: Port pricing; port tariff; ports' strategic planning; port cost; port competition.

I. BACKGROUND, OBJECTIVE AND SCOPE

Port privatisation and pricing

More than 50 countries privatised their port systems between 1991 and 1998.[1] The common privatisation program includes the transfer of stevedoring, yard handling, pilotage, line handling and gate security to private port operators, while ownership and control of basic infrastructure remains with a public or quasi-public port authority.[2]

Newly privatised ports had to develop new pricing systems, taking into consideration their own new institutional and operational structure, along with the competitive market environment created by their own and other regional ports' privatisation programs. Port pricing was recently studied in over 20 container ports in the Caribbean Basin, which encompasses the US Gulf Coast, Caribbean Islands, east and west coasts of Central America and the north coast of South America (NPWI, 1997; LBI, 1996). Based on the study and other support materials on pricing, this author developed a methodology for strategic pricing that was presented in the Seminar on Port Pricing and Financing for Latin America (OAS, 1998). This paper summarises the methodology and applies it to the case of Cartagena, a newly privatised port in Colombia.[3]

Review of port pricing literature

The professional literature on port pricing is concerned with two sets of topics. The first set relates to the pre-privatisation era, whereby pricing is addressed from the point of view of an operating, public port authority. Typical topics are: generating sufficient cash flows from 'historical' facilities to support new and costly facilities; distinguishing between short and long-term marginal social costs; enhancing asset utilisation through productivity incentives; and developing multi-level port tariffs, based on price elasticity of users.[4]

The second set of topics are primarily concerned with the technical aspects of port tariffs themselves, including the structure of tariffs, charging units, charging mechanisms (min/max), bundling of charges, and actual comparisons of charges at various ports.[5]

Neither the first nor the second group of publications directly addresses price setting considerations of newly privatised ports. This process is unique since it relates to the institutional/operational structure of the involved port and its competitors and is therefore referred to here as *strategic port pricing*. This process is the subject of this paper.

II. FACTORS AFFECTING PRICING DECISIONS

Port system with principal and intermediary parties

The discussion of port pricing in the pre-privatisation literature refers to the traditional port system consisting of three *principal* parties: a public operating port (the provider of port services) and two groups of private users (clients): shipping lines, and shippers. A convenient device to illustrate this institutional structure is a *node-link network*, whereby the parties involved appear as nodes and the services and charges that they exchange among themselves as arrows. Figure 1 presents in its upper portion the system of charges of a traditional, public port in the pre-privatisation era.

Newly privatised ports are distinguished by a more complex institutional structure, which includes *intermediary* parties along with the above-mentioned principal parties. The intermediary parties are private operators that provide port services using a combination of their own and port-owned facilities and equipment. Figure 1 presents in its lower portion the system of charges in a newly-privatised port. The pricing system here includes six principal charges (arrows):

1. The port charges stevedores for berth and yard wharfage[6] (P-O arrow in Figure 1);
2. The port charges lines for vessel dockage and cargo wharfage for empty boxes (P-L);
3. The port charges shippers for cargo wharfage for full boxes (P-S);
4. Stevedores charge lines for vessel stevedoring (O-L);
5. Stevedores (not necessarily the same ones that handle vessels) charge shippers for yard handling (O-S); and
6. Lines charge shippers for port handling to cover their port costs and those charged to them by other parties (L-S).

The last charge (6) is frequently included in the ocean freight bill as a separate surcharge called Terminal Handling Charge (THC).

Port system cost, direct and transferred charges

In light of the network-like charging system, port-pricing decisions should relate to: (a) the *total port charges*, or the summation of all its charges to principal and

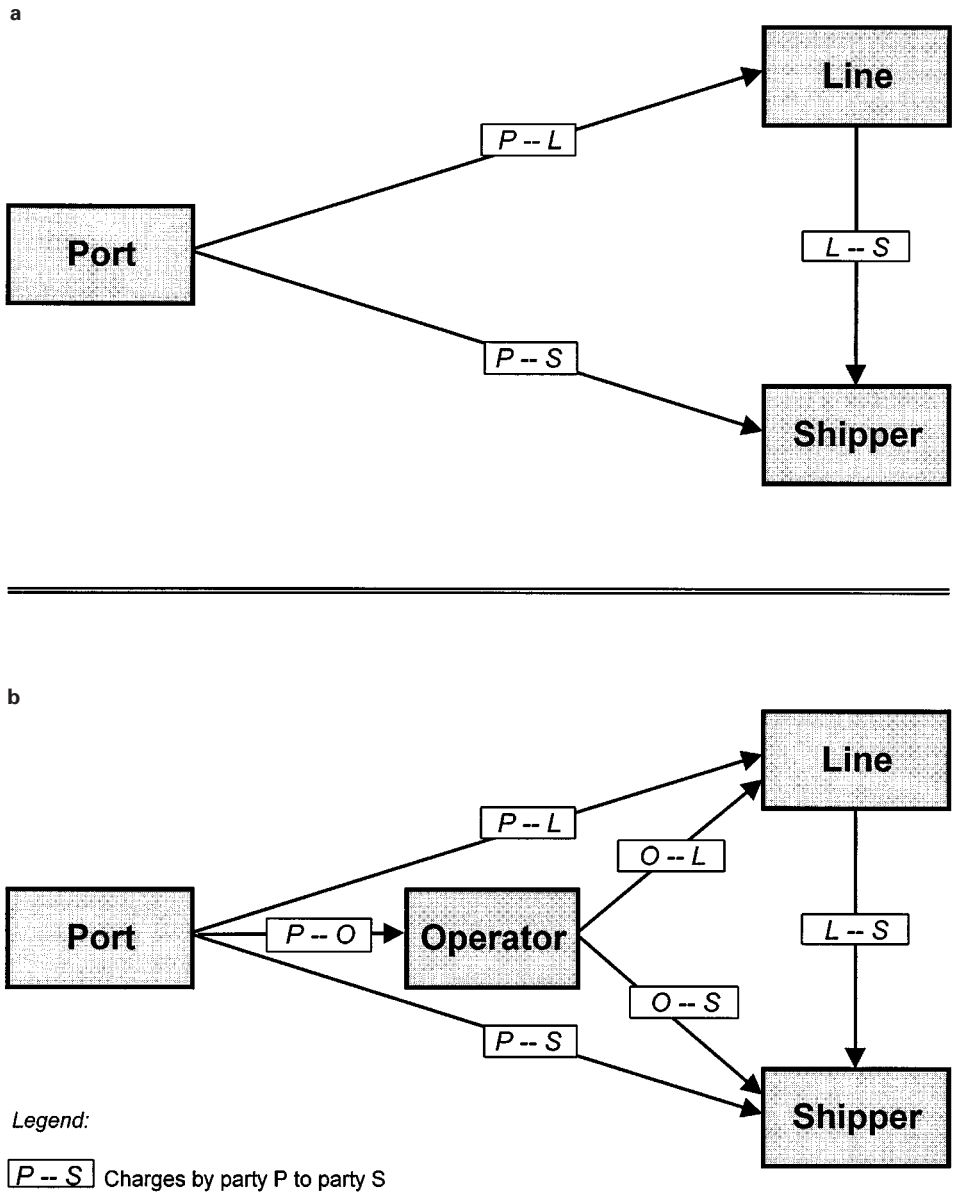

Figure 1: Columbian port setting a) before privatisation and b) following privatisation

intermediate parties; and (b) the *allocation* of these charges among parties. In determining this allocation the port has to consider both the direct and indirect charges, whereby indirect charges are defined as port's charges being *transferred* among parties.

For example, the total port charges are the summation of arrows emanating from P (P-L, P-O, P-S). The allocation relates to relative shares (%). The port's charge to the operator (P-O) may be fully or partially transferred by it to the line (O-L) and/or the shipper (O-S). The transfer process of charges may also involve two (or more) stages. For example, port charges to the operator may first be transferred by it to the line; then, the line may forward it to the shipper (P-O L-S).

Multi-layered structure and multiplicity of charges

In many privatised port systems operators hire other operators as subcontractors, creating *several layers of intermediaries*. For example, stevedores may contract out labour-intensive activities (eg lashing), reserving their own personnel for the more professional jobs (eg driving cranes).

Moreover, in reality, the number of services and charges in the port system may reach several hundred. The charges are not necessarily uniform, with tariff systems based on different charging units and charging schedules. For example, charges for crane services may differ in charging units (eg crane-hours or moves), time of service (eg straight or overtime), volume (eg a minimum with break points), etc. Also, in many developing countries, charges to lines are quoted in US dollars while charges to local shippers are quoted in local currency, with the latter constantly adjusted for inflation. A recent trend is to bundle the various individual charges into an *all-in* inclusive charge. Such bundling should facilitate cost comparisons among ports, except that ranges of services included in the all-in bundles may vary among ports.

Product differentiation and price discrimination

Presumably, all container terminals provide a similar basic service: the transfer of boxes between ship and shore. However, in reality even the basic service is highly differentiated. Containerships differ in configuration (eg Lo/Lo, Ro/Ro, Ro/Lo, geared/gearless) and dimensions (eg LOA, beam, draft) and therefore require different shore-based facilities (eg berth length and depth) and equipment (eg outreach and height of a gantry crane's boom). Operational layouts and handling processes of terminals may also differ (eg transfer boxes directly to trucks or only through the yard). Finally, lines and shippers may differ in their operational requirements (eg preferential ship berthing, guaranteed handling productivity, work on arrival, night operation of terminal gate).

Even if the technical and operational characteristics of clients are identical, different clients are often charged differently. Common discrimination factors are cargo values, cargo volumes, length of contract period, and cargo's origin/destination point: domestic containers may be charged more than transshipment containers; and domestic containers to/from a nearby hinterland may be charged more than those to/from a remote hinterland.[7]

Market concentration, rate fluctuations and government intervention

The overall market structure for providing port services in most world regions is highly concentrated and can be defined as oligopolistic, with the supply side typically consisting of three to five regional ports. There is also some concentration on the demand side, with most of the cargo carried by 10 to 20 lines. In contrast, the number of shippers is usually large. In a concentrated market situation, parties tend to behave strategically, considering responses by their competitors while taking price actions. This action/reaction mechanism often escalates to a full rate-war, resulting in rates moving up and down in wide fluctuations.

Because of high market concentration, ports are a frequent subject of anti-trust concern. Many countries maintain special-purpose port and shipping regulatory agencies. In the case of Cartagena, the relevant agency was the Superintendent of Ports of Colombia, which maintained a tariff control system based on tariff filing. The Superintendent also had the authority to launch an investigation following complaints of anti-competitive behaviour, including unfair pricing actions.

Multi-level competition

Another peculiar characteristic of the market for port services is its hierarchical nature, with the competition involving two levels:

- *Intra-Port Competition* between parties operating within the same port, such as between two operators; and
- *Inter-Port Competition* between port 'communities' or coalitions made up of the port, operators within the port and lines serving the port.[8]

As a result, the relationships between parties in the port system can be described as a mixture of competition and cooperation. For example, two operators that compete against each other in the intra-port level may cooperate in the inter-port level. The situation may become even more complex if it involves national operators that have regional subsidiaries in competing ports and may have conflicting interests.

Usually, the port organisation itself is more focused on the higher, inter-port level of competition. Presumably, the port is expected to lead the local port community in its struggle with other port communities. The ultimate subject of this struggle is cargo (shippers), for which the local port community attempts to offer a superior combination of: (a) handling services provided both by the port organisation and its operators; and (b) shipping services (ocean freight) provided by lines calling at the port.

Strategic factors and pricing analysis

Altogether, the setting of prices in newly privatised ports is distinguished by five *strategic factors*: (a) a network-like structure consisting of principal and intermediary parties; (b) wide variety of charges and charging mechanisms; (c) service differentiation and price discrimination; (d) high market concentration on both the demand and supply sides; and (e) a mixture of competitive and cooperative relationships among

parties. The strategic pricing analysis presented below revolves around the assessment of these factors.[9]

The assessment of these factors is also included in the port's *overall* strategic planning process. The common sequence of steps in the broader analysis includes: identification of the port's market threats and opportunities, appraisal of the port's internal and external resources, development and prioritising of goals, and devising strategies to efficiently deploy the port's resources for achieving these goals (Ashar, 1986). Pricing strategy is one of the strategies that can be employed to achieve the port's overall goals.

Paper's objective and scope

Newly privatised ports have implemented the strategic pricing process only in a rudimentary fashion.[10] The objective of this paper is to assist practitioners in newly privatised ports by providing them with a methodology for performing strategic pricing analysis. The proposed methodology includes four steps:

1. Analysing the port structure, identifying principal and intermediary parties and the services and charges that each party provides or receives;
2. Defining comparable port services and calculating a representative set of cost indicators;
3. Analysing the strategic factors (see above) and devising an overall pricing strategy; and
4. Determining specific pricing actions toward principal and intermediate parties in the port system.

The article presents two novel diagnostic tools to facilitate the application of the proposed methodology: (a) a *charge-flow diagram* for analysing the allocation of port charges among principal and intermediate parties; and (b) a *game tree* for analysing the port/competitors', action/reaction mechanism of competition in an oligopolistic setting. The methodology is illustrated by the case of the port of Cartagena, Colombia.

III. METHODOLOGY FOR PRICE AND COST COMPARISON

Functional division of port services

A port is conveniently defined as the range of facilities between the entrance buoy at the water access channel and the gate at the road and rail landside access. Port services provided within this range are commonly divided according to their principal recipients into:

- *Services to ships (lines)*; and
- *Services to cargo (shippers)*.

Both categories relate to physical services. Related administrative services are usually provided at no cost. In traditional operating ports, all services are provided by the public port organisation itself (port authority). In newly privatised ports, the services

are provided by a combination of the port organisation and private operators such as stevedores, yard operators, tug operators, etc. The port, lines and shippers were defined earlier as principal parties; private operators within the port are defined as intermediary parties.

Basic and auxiliary services

The number and diversity of services and related charges provided to ships and cargoes are large. Hence, to facilitate cost comparisons, port services are further divided into:

- *Basic Services* – essential activities necessary for a complete ship-to-shore (buoy-to-gate) transfer common to all ports; and
- *Auxiliary Services* – specialised activities that widely differ among ports.

Listing these services, classify them as basic/auxiliary, identifying parties that provide and pay for them, and calculating and comparing the respective charges are conducted in the first and second steps of the strategic pricing process. For example, handling boxes between ship and yard is a basic service, but handling boxes from ships directly to trucks is a special service that not all terminals provide on a regular basis and therefore considered an auxiliary service. The cost comparison, which is the basis for strategic analysis, only relates to basic services, typically a basket of about 20 services. However, analysis of auxiliary services is also part of the strategic evaluation, but it is included in the third step, which focuses on the means to differentiate a port from its competitors. Figure 2 presents a list of the main services for each category.[11]

Representative ship/cargo combinations

A common problem in cost comparison between ports is the wide variability in the population of ships and cargoes that each port handles. To account for this variability, the cost comparison is conducted for several representative *ship/cargo combinations* defined according to two sets of parameters:

- *Ship Characteristics* – including length overall (LOA), width, and draft; Gross Registered Tons (GRT), Net Registered Tons (NRT); hull configuration (cellular/non-cellular), cranes (number and type), hatch covers, etc.; and
- *Cargo Composition* – including number of moves per call and their breakdown by direction (import/export), content (full/empty), length (20/40-ft) and origin/destination (domestic/transshipment/rehandle).[12]

A ship (or vessel) move is counted every time a box is moved across an imaginary line between the ship and the edge of the docking structure. For cost calculation, a series of related yard and gate moves is added to the ship move according to their relative proportion in the complete ship-to-gate handling process.

Sample size

The number of representative ship/cargo combinations selected for cost comparison depends on the extent of variability in the population and on the pricing study's budget.

	Basic Services	Auxiliary Services
Ship Services	Use of Channel and Navigation Aids	Pilotage and Tuggage to/from Anchorage
	Pilotage between Ocean Buoy and Berth (In & Out)	Water, Electricity and Telephone
	Tuggage between Ocean Buoy and Berth (In & Out)	Security (Guard)
	Line Handling (In & Out)	Inspection, Immigration, Customs
	Use of Dock and Berth	Lashing/Unlashing Boxes on-board
Cargo Services	Handling Boxes between Ship and Yard	Special Handling: Direct to Truck, Overweights, Slings, etc
	Handling Hatchcovers	Handling Empties between Yard and Gate
	Use of Shore Cranes for the above	Storage of Boxes (beyond 'Free Time')
	Handling Boxes between Yard and Gate	Storage of Chassis and Breakbulk Cargo
	Intermediate Storage of Boxes ('Free Time')	Storage of Hazmat and Reefer Boxes
	Pre-stacking and Shifting Boxes in the Yard	Stuffing/Destuffing Boxes
	Inspection of Boxes and Equipment at Gates	Handling Boxes between Yard and Custom or CSF
		Weighing Trucks and Boxes
Admin Services	Preparing EIR, Dock Receipts, Location Cards, etc.	Preparing Stowage Plan, Crane Sequence, Stability
	Preparing Load Lists, Equipment Inventory, etc	

Figure 2: Categorisation of port services

In Cartagena, the sample was limited to two representative cases: (a) the relatively large ships of New Caribbean Service with an average of 407 moves, 38 of which transshipment moves; and (b) the relatively small ships of American President Lines (APL) with an average of 118 moves, 50 of which transshipment moves. Another reason for selecting these ships was that they also called at competing ports, a fact that facilitated comparisons.

Port cost indicators

Port cost refers to a basket of basic services provided to a representative combination of ship and cargo. In Cartagena's strategic pricing analysis, the cost comparison was conducted according to six cost indicators, each addressing a different aspect of the pricing strategy. The indicators were:

- *Single Item Cost* – related to providing a specific and mostly limited port service, usually included in a single tariff item;
- *Total Costs* – related to providing the full range of basic services to a ship/cargo combination and measured by the average (unit) cost per move and per TEU[13];
- *Total Domestic Cost* – the portion of the above total cost which relates to domestic moves (excluding transshipment but including re-handles), divided by the number of full (freighted) domestic moves;
- *Marginal Domestic Cost* – the incremental cost for one additional move of a full FEU of domestic cargo;
- *Marginal Transshipment Cost* – the increment to the total cost for handling one additional move of a full FEU of transshipment cargo; and
- *Marginal Ship Costs* – the total cost, for a ship with no cargo and no related charges for handling it (zero moves).

Figure 3 summarises the definitions of the above indicators.

Application of cost indicators

Comparing *single item costs* is mainly useful for determining charges for individual services. Seemingly straightforward, the calculation process is often complex. For example, several Caribbean ports have recently acquired expensive ($3.5-4 million) harbour mobile cranes to handle containers. The ports used different charging units and rate schedules for their cranes, with some ports charging by the hour and others by the move. The hourly and per move rates were based on different combinations of fixed (minimum) and variable portions. The hours of usage were also defined differently, including/excluding times for crane relocation, stand-by, etc. Likewise, there was no uniformity in the definition of moves, especially relative to the inclusion/exclusion of rehandles and hatch covers. Altogether, the cost comparison of this seemingly simple item required many operational assumptions and respective adjustments.

Total costs serves as the main input for deciding on the overall price level, since it includes the cost of using a port for all parties. This indicator involves the aggregation of about 20 single-item costs defined as basic services, each single-item

Name of Indicator	Definition
Tariff Item:	
Per Specific Service	Charges for an individual service (including minimum volume discounts)
Total Cost:	
Per Ship Call	Charges for Basic Services provided to a Representative Ship/Cargo combination
Average Cost:	
Per Move	Total Cost divided by the number of moves (Full & Empty; I/E & Trans)
Per TEU	Total Cost divided by the number of TEUs (Full & Empty; I/E & Trans)
Per Freighted Domestic	The domestic portion of Total Cost divided by the number of Full Domestic Move
Marginal Cost:	
Per Ship Call	Total Cost assuming a ship with no (zero) cargo
Per Full Domestic FEU	Change in Total Cost for adding a domestic FEU to a Representative Ship/Cargo combination
Per Full Trans FEU	Change in Total Cost for adding a transshipment FEU to a Representative Ship/Cargo combination

I/E = Import and Export (Domestic Cargo)
Figure 3: Port cost indicators

calculation requiring assumptions and adjustments as noted above. In addition, there are manipulations related to the composition of items included in the baskets of basic services as defined in the ship/cargo combinations. For example, the calculation should relate to ship handling equipment (eg ships' gear, shore crane or a combination), time of service (eg working on arrival or waiting till next shift schedule), etc.

The *cost of a freighted domestic move* is the equivalent of the Terminal Handling Cost (THC), a major charging item included in the shipping lines' ocean freight. This indicator is relevant for gaining insight into a line's consideration for port selection. It may also be used by regulators to verify that the THC in the line's tariff is in accord with the actual port cost.

Marginal cost indicators are used to gain insight into a line's consideration for selecting ports for handling *discretionary* cargoes. For example, a line considering a regional hub and feeder deployment and related transshipment would be interested in comparing marginal costs of transshipment in each of its ports of call in the region. Likewise, a line considering adding a port of call to avoid transshipment should be interested in the marginal cost for a ship call.

Price/cost comparison model

The calculation of costs for a series of representative ship/cargo combinations is a tedious undertaking, involving a compilation and manipulation of a large number of

tariff items. To facilitate this process in the case of Cartagena, a computation model was developed, consisting of a database of tariff items linked to a summary spreadsheet. The model was specifically designed to facilitate testing the sensitivity of the cost indicators to changes in tariff items and operational assumptions.

Charge-flow diagram

Another useful tool developed for the cost analysis was a detailed flow chart of charges in the port system, defined as a *charge-flow diagram*. This diagram, an extension of Figure 1, identifies services and charges in the port system according to service providers, service recipients, and payees. The diagram's nodes represent parties involved in the port system; the links (arrows) represent charges in the system. Basic charges appear in solid lines and auxiliary charges in dotted lines. Figures 4 and 5 present charge-flow diagrams of Cartagena and Miami, with the components of the cost for a full domestic move for an APL ship. All data refer to 1996.

Institutional setting in Cartagena and Miami

Each of the six Colombian and four non-Colombian ports included in the price analysis had different charge-flow diagrams, reflecting the different organisation and operation structures of their ports. For illustration purposes, only two terminals, the Port Company of Cartagena's terminal and Miami's POMTOC[14] terminal, are discussed here. The main difference between the two was in terminal handling. In Cartagena, stevedores (operators) provided both ship stevedoring and terminal handling, with stevedoring charged to lines and terminal handling to shippers. In Miami, stevedores provided ship stevedoring, like Cartagena; yard handling was provided by POMTOC, a terminal operating company, and charged to lines. Also, in Cartagena, the allocation of yard areas to lines and shippers and charging storage for using these areas were by the port. In Miami, the port functioned as a landlord port and the terminal was managed by POMTOC.

Flow chart of charges in Cartagena and Miami

Cartagena had a complex charge-flow diagram, based on separate charges for berth and yard wharfage ('use of installation') to shippers, operators, and lines (for empty boxes only). The port charged operators for crane usage on an hourly basis and lines for dockage. Operators charged lines for ship handling and shippers for yard handling, with their charges incorporating, presumably, the respective charges they paid to the port. Another charge peculiar to Cartagena was a user fee imposed by the port on pilots and tug operators for allowing them to use Cartagena's facilities.

Miami's charge-flow diagram was diametrically different from that of Cartagena, with the port having no direct charge to shippers. The port charged cargo wharfage to lines based on a uniform tonnage rate regardless of cargo value. The port also charged a small harbour fee based on ships' GRT. An additional harbour fee was collected by the US Federal Government through Customs, based on 0.075% of the cargo value. The port charged POMTOC an annual rental fee, unrelated to volume. POMTOC charged

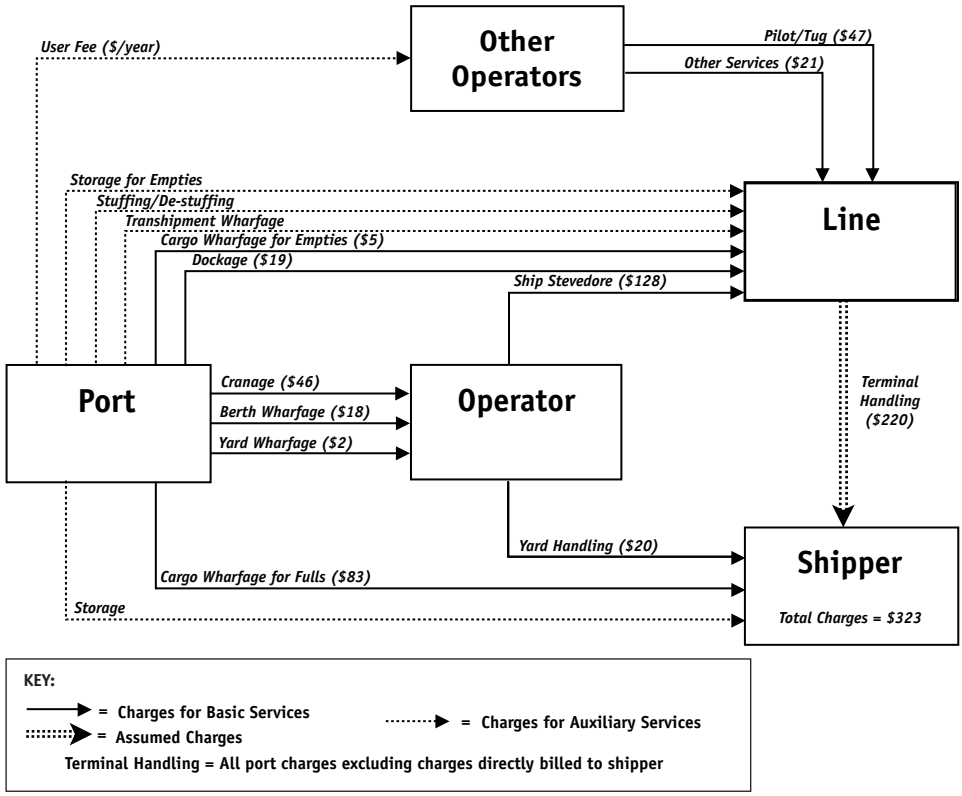

Figure 4: Flow of port charges at SPR Cartegena ($/full domestic move)

lines a uniform handling fee per box (gate charge), regardless of size (20/40 ft), direction (import/export), and content (full/empty).

IV. RESULTS OF COST AND PERFORMANCE COMPARISON

Market segmentation

The market for port services was already observed in Section I to be stratified, comprising of intra-port and inter-port levels of competition. The following analysis relates to the inter-port level, the competition between 'port communities', which was observed as the most critical in the case of the Port of Cartagena. This competition involved two related market segments:

- *The Market for Domestic Colombian Containers* – handling Colombian import and export (I/E) boxes, where Cartagena competed with five other Colombian ports; and
- *The Market for Caribbean Transshipment Containers* – handling foreign boxes that originated from or were destined to non-Colombian ports, where Cartagena competed with about 15 Caribbean ports.

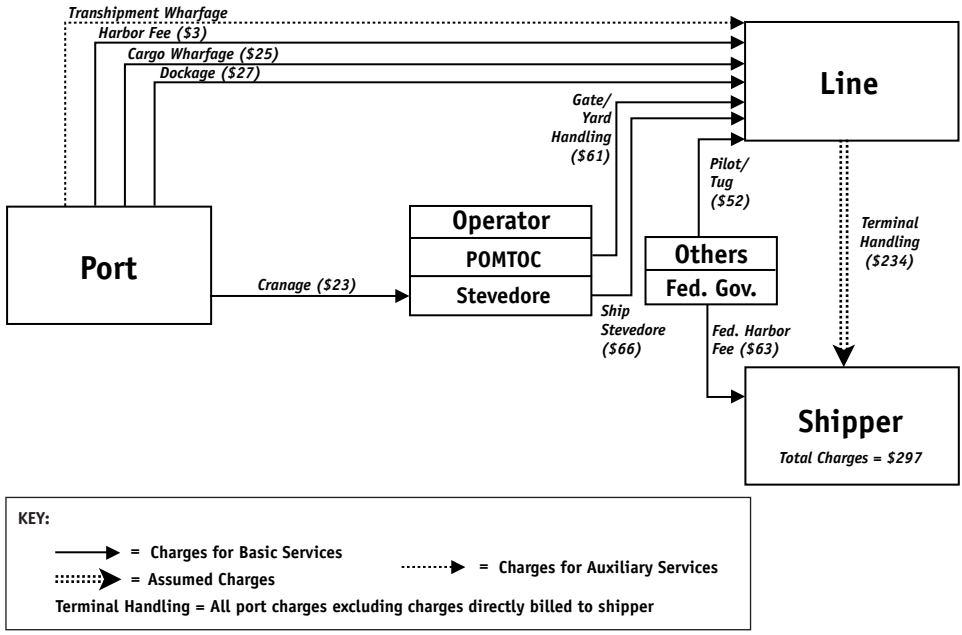

Figure 5: Flow of port charges at Port of Miami ($/full domestic move)

Accordingly, cost comparisons related to two types of boxes, domestic and transshipment, with each encompassing a different range of ports. Figures 6 and 7 present the results for the APL ship, the 'small' ship in the sample. Similar calculations were conducted for an NCS ship but are not presented here.

Comparative assessment of costs for Colombian ports

As Figure 6 shows, the total cost for handling the APL ship, based on an average of six Colombian ports, was $23,943; the respective unit costs were $203 per move and $134 per TEU. Cartagena's costs were $23,592 per ship, $200 per move and $132 per TEU, very close to the Colombian average. The difference in total cost between Cartagena and the lowest-cost port, El Bosque, was $2,891 ($24 per TEU), or about 12%. Cartagena's marginal cost for domestic boxes of $218 per full FEU was below the average of $220, but still $14 above the lowest cost port, El Bosque. Its marginal cost for transshipment FEU of $107 was lower than the average of $125, and only $3 higher than that of its closest competitor, El Bosque. Apparently, Cartagena's pricing system was geared toward transshipment more than its Colombian competitors.

Comparative assessment of costs for Caribbean ports

As Figure 7 shows, Cartagena's average costs, at $195[15] per move and $128 per TEU, were below the average of the five Caribbean ports selected for cost comparison. Kingston, Jamaica had the highest average cost at $326 per move and $134 per TEU, followed by Cristobal, Panama. Miami's cost was surprisingly low at $168 per move and $111 per TEU. The lowest costs were recorded in Rio Haina, the Dominican

I. Representative Ship/Cargo

Vessel characteristics		Cargo Composition					
LOA (m)	150	Moves (Boxes)	118	I/E Full Boxes	56	Trans Full Boxes	41
GRT (tons)	10,238	TEUs	179	I/E Mty Boxes	12	Trans Mty Boxes	9
NRT (tons)	5,880	TEU/Box Ratio	1.52	I/E Boxes-total	68	Trans Boxes-Total	50
		Re-handle	–	Total/Full Ratio	1.21	Total/Full Ratio	122

II. Absolute Costs

	Total Cost	Average cost			Marginal Cost		
Port	per Ship	Move	TEU	I/E Full Box	Ship Call	I/E Full FEU	Trans Full FEU
Cartagena	23,592	200	132	323	4,880	218	107
Contecar	23,811	202	133	317	4,880	211	122
El Bosque	20,701	175	116	283	4,032	204	104
Barranquilla	26,465	224	148	352	5,180	243	144
Santa Marta	22,332	189	125	299	4,520	205	122
Buenaventura	26,758	227	149	349	4,910	240	151
Average	23,943	203	134	321	4,734	220	125

III. Cost Differentials

Cartagena	–	–	–	–	–	–	–
Contecar	219	2	1	(6)	–	(7)	15
El Bosque	(2,891)	(25)	(16)	(40)	(848)	(14)	(3)
Barranquilla	2,873	24	16	29	300	25	37
Santa Marta	(1,260)	(11)	(7)	(24)	(360)	(13)	15
Buenaventura	3,166	27	18	26	30	22	44

IV. Relative Cost Differentials

Cartagena	0%	0%	0%	0%	0%	0%	0%
Contecar	1%	1%	1%	−2%	0%	−3%	14%
El Bosque	−12%	−12%	−12%	−12%	−17%	−6%	−3%
Barranquilla	12%	12%	12%	9%	6%	11%	35%
Santa Marta	−5%	−5%	−5%	−7%	−7%	−6%	14%
Buenaventura	13%	13%	13%	8%	1%	10%	41%

I/E = Import & Export
Note: Average Cost per Full I/E Box relates to the domestic portion of the Total Cost per Ship.

Figure 6: Cost indicators for Colombian ports; APL service using mobile crane

I. Representative Ship/Cargo

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		Re-handle	–	Total/Full Ratio	1.21	Total/Full Ratio	1.22

II. Absolute Costs

	Total Cost	**Average Cost**			**Marginal Cost**		
Port	**per Ship**	**Move**	**TEU**	**Full I/E Box**	**Ship Call**	**Full I/E FEU**	**Full Trans FEU**
SPRC	22,992	195	128	317	4,880	216	105
Miami	19,843	168	111	297	4,619	191	66
Kingston	38,409	326	215	539	2,958	397	167
Rio Haina	15,861	134	89	187	1,848	148	86
Cristobal	28,253	239	158	405	5,326	270	110
Average	25,072	212	140	349	3,926	244	107

III. Cost Differentials

SPRC	–	–	–	–	–	–	–
Miami	(3,149)	(27)	(18)	(20)	(261)	(25)	(39)
Kingston	15,417	131	86	222	(1,922)	181	62
Rio Haina	(7,131)	(60)	(40)	(130)	3,032)	(68)	(19)
Cristobal	5,261	45	29	88	446	54	5

IV. Relative Cost Differentials

SPRC	0%	0%	0%	0%	0%	0%	0%
Miami	−14%	−14%	−14%	−6%	−5%	−12%	−37%
Kingston	67%	67%	67%	70%	−39%	84%	59%
Rio Haina	−31%	−31%	−31%	−41%	−62%	−31%	−18%
Cristobal	23%	23%	23%	28%	9%	25%	5%

I/E = Import & Export
Note: Average Cost per Full I/E Box relates to the domestic portion of the Total Cost per Ship.

Figure 7: Cost indicators for Caribbean ports; APL service using gantry crane

Republic, at $134 and $89 per move and TEU, respectively. Another surprising result was the high cost per full domestic move in Kingston of $539. It should be noted that the range of costs among Caribbean ports was much wider than that in Colombia. For example, the per TEU cost in the Caribbean ports ranged from $89 to $215 (1: 2.42), *vs* $116 to $149 (1: 1.28) in the Colombian ports.

Cartagena's marginal cost for transshipment, at $105 per full FEU, was slightly below the average of $107 and almost twice the cost of the least expensive port, Miami, at $66. However, Miami's cost excluded overtime charges and other labour-related direct and indirect charges that would have driven the cost much higher. A more relevant competitor for Cartagena in the transshipment market segment was the second lowest cost port, Rio Haina, with $86 per full FEU, or about 18% below Cartagena's.

Another interesting comparative figure is the ratio between marginal costs for domestic and transshipment, which in Kingston, Jamaica, reached 2.38 *vs* 2.05 in Cartagena. It seemed that Kingston was practising the highest price discrimination between domestic and transshipment containers.

Complementary assessment of service levels

The foregoing analyses encompass the first and second steps of the strategic pricing methodology, which related to the definition of parties and charges and calculation of cost indicators (Section II). The third step of this methodology involves the analysis of the strategic factors, key among them being the level of services and the related service differentiation.

Level of service in the port industry consists of two major components: technical capability and performance. Technical capability relates to the characteristics of terminal facilities and equipment, such as channel depth, berth lengths, number and dimensions of shore cranes, etc. Performance, from the point of view of users, is measured by a combination of availability and productivity. Both relate to the time users spend in the system, which consists of the time before (waiting) and during service. Assessing availability of facilities requires the analysis of port capacity and the overall relationship between demand and supply for port services. Since a detailed analysis was beyond the scope of the paper, only a preliminary, qualitative assessment was conducted. Partial performance data, as defined by common performance indicators (eg berth utilisation, average hours of ship waiting, moves per berth-hour), were available and incorporated into the analysis.[16]

Comparative assessment of service levels of Colombian ports

The overall capacity of Colombian ports for handling containers was observed to be generally sufficient and capable to absorb the short-term growth without congestion. More important was the fact that Cartagena was the only port that could provide modern gantry services in Colombia during the study period (summer of 1996), while the rest of the Colombian ports had only mobile harbour cranes.[17] In addition to the gantry, Cartagena had a mobile crane so, if needed, the port could serve ships with two shore cranes. Also, Cartagena had: (a) a much larger number of container berths than its competitors; (b) higher operational productivity; and (c) more advanced yard control system. In short, Cartagena's capabilities and performance were much higher than its Colombian competitors.

Due to its superior facilities and performance, Cartagena gained a dominant market position on the Atlantic (Caribbean) coast of Colombia, handling two thirds of the regional cargo. The port also had the largest selection of lines calling there, providing a superior connectivity to Cartagena's shippers.

Comparative assessment of service levels of Caribbean ports

The overall port capacity for transshipment and domestic containers in the Caribbean Basin was much larger than their throughput. The overcapacity situation was attributed mainly to the inauguration of the Gordon Cay in Kingston, Jamaica, and the construction of a new section at the MIT terminal in Manzanillo, Panama. In addition, during the study, two new large port construction projects were announced in Panama, in Coca Solo (by Evergreen Lines) and in Cristobal (by HIT).

Cartagena's facilities were inferior to those available at the larger Caribbean ports specialising in transshipment. This inferiority was particularly evident in the technical capability to handle large Panamax and post-Panamax ships. Cartagena was designed to handle second generation containerships, while the new terminals in Cristobal and Kingston were designed for fifth generation post-Panamax containerships and for large-volume transshipment operations.

V. STRATEGIC EVALUATION AND RECOMMENDATIONS FOR PRICE ACTIONS

Defining alternative pricing strategies for domestic containers

The previous section assessed Cartagena's relative position in terms of cost and performance in the markets for domestic and transshipment containers. The conclusion was that due to Cartagena's inferior facilities, its prospects of becoming a major Caribbean transshipment hub were slim. Hence, Cartagena should aim its pricing strategy to the domestic market, focusing on within-Colombia competition. The main observations regarding this market were: (a) Cartagena had a dominant position, handling about two thirds of the cargo; (b) Cartagena's cost, as measured by the total port cost indicator, was average; and (c) its technical capabilities and service level were superior.

The above observations gave rise to two diametrically opposite pricing strategies for Cartagena:

- *Raise* – a modest increase of rates; and
- *Slash* – a radical reduction of rates.

The first strategy was based on the apparent imparity between cost and service level. The underlying hypothesis was that most of Cartagena's users would be willing to pay a small premium for a superior service. While there could be a small diversion of cargo from Cartagena to its competitors, its impact would be compensated by the higher revenues generated by the remaining cargoes.

The underlying hypothesis in the second strategy was that it would induce a large diversion and eventual desertion of the market by Cartagena's competitors, who were much smaller in size and inferior in facilities. These ports might choose to invest their limited resource in cargoes in which they had relative advantages (eg coal, steel) and where Cartagena was only marginally involved.

The two strategies defined above also reflected the two contradicting views of the port staff. The marketing people were advocating a price reduction, fearing the loss of

market share. The finance people were advocating a price increase, stating that cash flows generated by current operations would not be able to support further investments in container facilities and equipment. They also indicated that Cartagena, with a higher cost of production, could not sustain for too long the market price dictated by its lower cost competitors.

Game *vs* decision tree

A game tree, an analytical tool based on decision and game theory, was developed to facilitate the analysis of the pricing strategies. A decision tree has three elements: (a) a decision node, from which several, mutually-exclusive decisions emanate; (b) several uncertain events that follow these decisions, each assigned a probability; and (c) results or pay-offs for each decision/event pair. A game tree is a decision tree, where decisions are substituted by strategies (actions) and uncertain events by competitors' responses (reactions). The main difference between the two theories is in assessing event probabilities (b). In decision theory, the decision-maker plays against nature. Hence, the events that follow his/her decision are independent of the decision. In game theory, the player's action triggers competitors' responses, which, in turn, depend on their perception of the impact of the action on their situation.

Redefining Cartagena's situation using a game tree

Cartagena's pricing strategies (actions) were defined before as Raise or Slash. Competitors were assumed to select one of two alternative responses:

- *No Change* – keep price unchanged; and
- *Match* – adjust price to that of Cartagena.

The results of the price actions and responses were to be quantified in two related areas: cargo volumes (TEUs) and profit ($). The preferred strategy would be that which maximises Cartagena's expected profits. In addition to the two explicit strategies, there was a third implicit strategy of '*do nothing*', or keep rates unchanged.[18]

Assessing the results of price actions

The estimation of financial pay-offs was done through a simple financial model, based on the analysis of the port and its competitors' income statements. The analysis indicated that fixed costs accounted for about 50% of revenues, variable costs for 45%, and profits (net income) 5%. The high proportion of fixed costs and low profit margins indicated that a small change in volume and/or rates would result in wide profit fluctuations.

To simplify the game-tree analysis, the Raise and Slash strategies were defined as +5% and −20% changes in rates respectively. It was assumed that deeper cuts in rates were required to induce diversion of larger volumes of cargo. Based on discussions with the port staff, local shippers and ship agents, Cartagena's price elasticity of cargo was estimated to decrease from three to one along the relevant range of rate changes. For example, in the Raise/No-Change case, a rate increase of 5% was expected to divert 12.5% of Cartagena's cargo, which would result in profit

reduction of 50%. The 12.5% reduction in Cartagena's cargo was equal to a 25% increase in its competitors' cargo volume and would result in a respective increase in their profit of 500% (five times the present profit). In the Raise/Match case, there would be no cargo diversion and both Cartagena and its competitors were calculated to benefit from a 100% increase in profit.

In Slash/No-Change, where competitors stuck to their rates while Cartagena slashed its rate by 20%, Cartagena would increase its volume by 20%, while its profit would decrease by 260% (incurring a loss equal to 2.6 times the base-case profit).[19] The impact on competitors would be a loss of 40% of their cargo and 800% of their profit. In Slash/Match, where competitors matched the rate slashing, there would be no diversion and both Cartagena and its competitors were calculated to lose 400%. Figure 8 presents a schematic illustration of the game tree.

Estimating response probabilities

The most challenging part of the game-tree modelling was the estimation of response probabilities by competitors. In the case of Raise, competitors would certainly prefer the higher profit of the No-Change response. However, it was estimated that competitors would also realise that a Raise/No-Change situation would not last long. Once Cartagena observed that competitors were not following its price leadership, it would reinstate its previous rates, or even resort to a rate cut.[20] In contrast, the Raise/Match seemed to be a win-win, stable situation. Consequently, following an analysis of past competitors' behaviour, a probability of 20% was assigned to the No-Change and 80% to the Match response.

In the case of Slash, it was estimated that competitors would most probably respond in kind, or Match. The prevailing belief was that competitors perceived containers as essential and therefore were likely to cling to them even at the cost of a prolonged rate war. Still, there was some probability that these ports would decide not to join the price slashing, give up on some of their cargo and, over time, adjust their cost structure to lower volumes. Consequently, a probability of 80% was assigned to the Match and 20% to the No-Change response.

Regulatory response

An additional major concern was a possible regulatory intervention by the Port Superintendent of Colombia claiming: (a) collusion in case of a significant, industry-wide rate increase; or (b) predatory practices in case of radical price slashing followed by a large diversion. Estimating the financial implications of such regulatory intervention was not attempted. However, because of this concern, a very aggressive strategy specifically aimed at lines that double call at Cartagena and its competitors was rejected. This strategy involved granting a special 'diversion discount' to these lines to encourage them to concentrate their cargo in Cartagena. Lines that call at both Cartagena and another Colombian port were the most susceptible for diversion, since by eliminating the second call and concentrating all their cargo in Cartagena they would save the port entry cost as measured by the marginal cost per ship call (Figure 3). Such a diversion discount intended to lower the *marginal cost indicators* discussed in Section III.

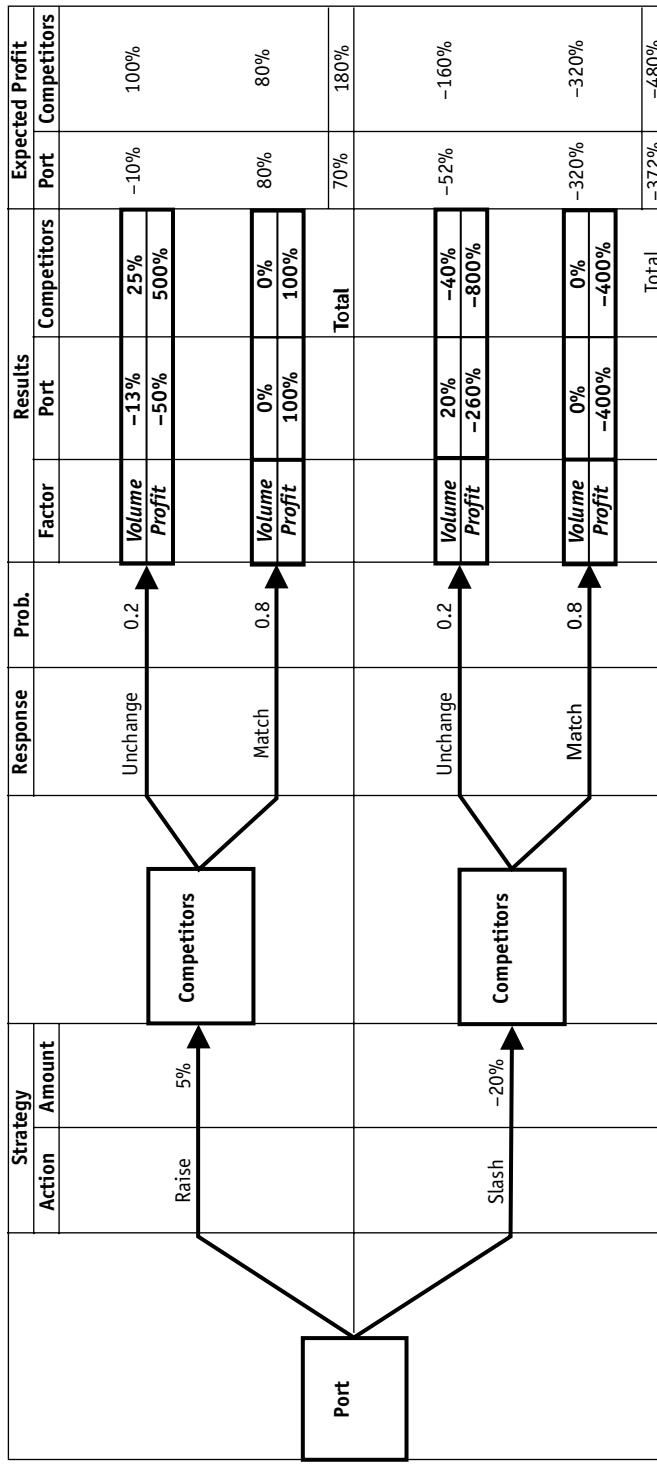
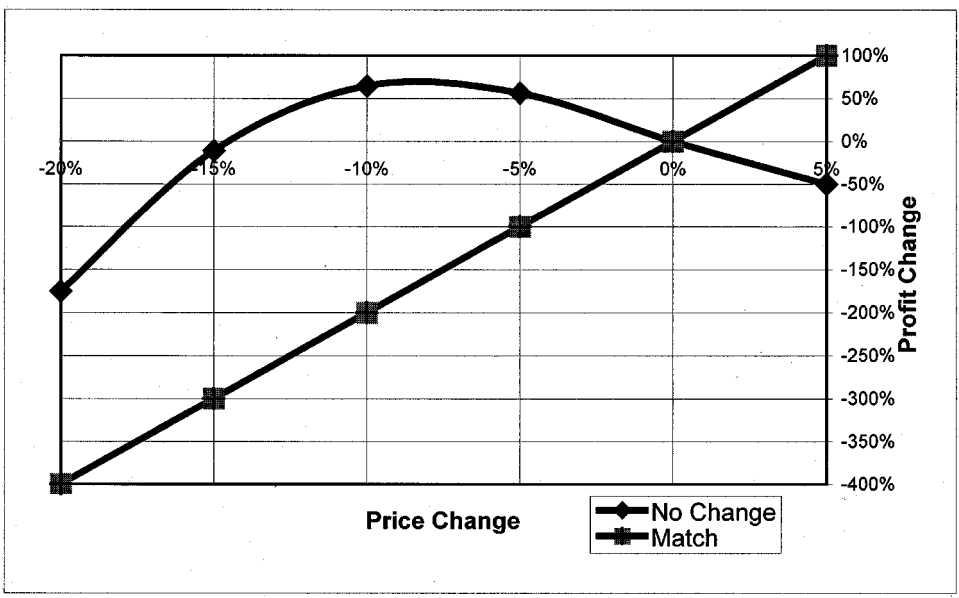


Figure 8: Game tree for pricing strategies

Recommended strategy

The expected profits were calculated by multiplying payoffs by probabilities. The Raise strategy was highly superior, generating 70% increase in expected profits *vs* 372% reduction for the Slash strategy. Hence, the overall recommended strategy was a general rates increase of about 5%.

A sensitivity analysis assessed other price actions within the range of −20% to +5%, using the same game tree format. The analysis indicated that price actions involving changes between 0% and −13% would be profitable under the No Change response, and between 0% and +5% under the Match response. Other sensitivity tests, not included here, examined the effects of various assumptions on competitors' responses, price elasticities, and financial structure. Figure 9 presents the results of a sensitivity analysis relating changes in profit to price actions, assuming the two response strategies (No-Change, Match).



Change in Rates	Response Scenario	
	No Change	Match
5%	-50%	100%
0%	0%	0%
-5%	56%	-100%
-10%	65%	-200%
-15%	-11%	-300%
-20%	-175%	-400%

Note: Negative profit denotes a loss. Eg -100% profit means a loss equal to the base-case profit.

Figure 9: Port profit as a function of price and response scenario

Selected rate increase

The recommendation for a general rate increase of about 5% concluded the first step of the strategic pricing analysis. A follow-up analysis had to determine: (a) how to allocate their rate increases among the various parties: shippers, lines, or intermediate operators; and (b) what charges rendered by the port to these parties should be raised and by how much. In terms of the node-link port system as presented in Figure 1, the analysis had to determine which of the arrows would have to be modified and by how much, subject to the constraint that the change in total cost, as measured by the total cost indicator, should not exceed 5%.

Increase in shippers' wharfage

Cartagena was the largest Colombian port on the Caribbean Coast, with the widest selection of lines and maritime connections. Shippers who needed this connectivity and selectivity of services did not have much choice. Therefore, shippers, especially smaller ones, who did not exert much influence, were considered more susceptible to a rate increase. Cartagena's lines were not involved in providing land transport services and thus seemed indifferent to a modest rate increase, as long as their shippers would pay it directly to the port. Hence, the first recommendation was for an increase in cargo wharfage beyond 5%, at about 10%.

Cartagena, as seen in the charge-flow diagram in Figure 4, had a peculiar structure of charges, with three wharfage charges: to shippers, ships, and operators. The largest wharfage, at $83 per full domestic move, was charged directly to shippers. Accordingly, an increase of 10% in shippers' wharfage was expected to generate a hefty increase in revenues.

Increase in shippers' storage

Most of Cartagena's shippers required storage time beyond the free time due to a combination of delays in customs processing, difficulties in arranging land transportation, and shortage in secured storage space outside the port. The storage of full boxes, beyond free time, was an auxiliary service paid for by shippers directly to the port. Cartagena's storage rates, at $25 per day for a full 40-foot box, were already higher than those of competing ports. Nevertheless, it was estimated that an increase in storage rates would be absorbed by shippers, who were also aware of the need to relieve yard congestion. Moreover, it was expected that lines, looking to expedite the retrieval of their boxes, would be supportive of such an increase. Hence, the recommendation was to significantly surpass the general rate increase of 5% and impose a steep 20-30% rate increase in shippers' storage charges.

'High, medium and low-tech' lines

The ultimate clients and payees of port services and prices are cargo owners or shippers. Nevertheless, in Colombia (as well as in many ports worldwide) shipping lines were observed to have the upper hand in selecting ports through which 'their' cargoes would flow. Colombia's lines were divided into three categories in terms of technical specifications of their operations:

- *High-Tech Lines* – those requiring shore cranes and a specialised yard;[21]
- *Mid-Tech Lines* – those that might benefit from shore cranes and a specialised yard, but could do without them; and
- *Low-Tech Lines* – those that did not require shore cranes and a specialised yard.

Cartagena, being a high-tech port, handled almost all of the high-tech lines and about half of the mid-tech, while most of the low-tech lines were handled by competing ports.

Enhance the use of shore cranes

High-tech lines were the main beneficiaries of the declining rate schedule of shore cranes. The rate scheme included a base rate of about $500 per hour and a volume discount of up to $200 per hour. The discount was granted when the cranes were first installed in order to attract users. However, even with discounts, since the total volume handled by high-tech lines was relatively small, the cranes were only partially utilised.

Most of Cartagena's moves were attributed to the mid-tech lines. These lines had a relatively small number of moves per call, and did not qualify for discounted rates. For most of them, using shore cranes at full cost was not justified by gains in productivity and the related savings in gang and ship times. In terms of overall volume, mid-tech lines accounted for most of the containers handled in Cartagena.

The recommended pricing strategy was aimed to induce mid-tech lines to use the under-utilised shore cranes. It was suggested to convert the pricing scheme to a flat rate with a small minimum to deter short-period usage by low-tech lines. The flat rate was set equal to the average rate that the high-tech lines were paying. There was no need to lower the rate for high-tech lines, since they were assumed captive to Cartagena. Another proposed change was to convert the charging unit from per-hour to per-move. The per-move rate was set at the equivalent average charge of the previous hourly rate, keeping the overall crane charge to the high-tech lines unchanged. The transition from per-hour to per-move pricing was intended to facilitate 'all-in' pricing (see below).

The promotion of crane usage through pricing was in line with Cartagena's overall strategy of fostering technological superiority. More specifically, it was expected that the additional usage of cranes would justify the investment in a second gantry crane, placing Cartagena further ahead of its gantry-less competitors.

Operators charges and role

Extensive discussions with operators and lines served by them revealed that operators were essentially a conduit of port charges to lines and shippers. Most operators even included port charges as separate tariff items in their invoices. Any rate increase to operators would therefore lead to an equal rate increase to shippers and lines.

A more fundamental subject, the role of port operators, was also raised during these discussions. Operators were relatively small and lacked financial resources to undertake investments in new and expensive equipment (eg yard cranes). Such investments could only be recovered by large volumes, which were beyond the reach of a single operator. However, installation of yard cranes was considered critical for enhancing capacity and for keeping up technological superiority. Hence, the recommendation was for the port to pursue a consolidation program by bidding and contracting the entire operation on an

exclusive basis. A more preferable option, that the port would conduct the operation with its own staff, was not permitted by the Port Superintendent.

All-inclusive per-move charge

Following the proposed consolidation of port operations, the port would be able to provide and charge lines directly for a complete ship-to-yard service, consisting of basic services (see Section III). The service would be charged on a per-move basis, with rates following a similar scheme as the crane charge discussed above. This pricing strategy was expected to induce self-screening among lines. High-tech, high-volume lines would be attracted to Cartagena, while the low-tech, low-volume lines diverted to its competitors.

Pricing transshipment containers

Efficient transshipment operations require matching mother and feeder vessels and handling large volumes of boxes during a short time. This, in turn, requires large facilities equipped with a large number of cranes unavailable in Cartagena. Cartagena's capabilities were already observed to be inferior to those available in the large transshipment terminals of the Caribbean Basin. Moreover, since Cartagena's facilities were relatively small, handling large volumes of transshipment would adversely affect Cartagena's level of service for domestic cargo.

The competition for transshipment cargoes was much more intense than that for domestic cargoes, resulting in market rates for transshipment at about 40-50% of those for domestic containers (see Section III). Also, unlike domestic cargoes, transshipment did not generate additional revenues from auxiliary shippers' services such as storage and CFS. Consequently, the recommendation was to not attempt to attract transshipment by special pricing actions. Interestingly, this recommendation was in sharp contrast to the prevalent pricing policy in most Caribbean ports, including Cartagena.

Specific rate recommendations

Altogether, the recommended price actions included:

- Modest (10%) increase in wharfage for shippers;
- Substantial (20-30%) increase in storage rates for shippers; and
- No change in shore crane rates, except for a change in the rate structure.

In calculating the specific rate changes, the port had to make sure that the total port cost, as measured by the respective Total Cost and, especially, Total Domestic Cost indicators (Section III), would remain within the 5% range of the overall recommendation for cost increase. An additional institutional recommendation was to consolidate the basic ship and cargo services into an all-in service billed by the port.

Tacit allocation of the market

A key assumption in the analysis of Cartagena competitors' response was that based on past experience they would realise the senselessness of a price war and the advantage of cooperation. Still, there was a concern that Cartagena's rivals might misinterpret the recommended price actions.

In light of this concern, a final recommendation was made: to clarify Cartagena's overall market strategy along with the upcoming price actions. Cartagena should openly declare its long-term interest in preserving the *status quo* based on 'specialisation', with Cartagena focusing on the higher-tech market segment that better suits its facilities, leaving the lower-tech segment to its competitors. Then, in line with its declared interest, Cartagena should announce the need for a modest rate increase to support further investments in high-tech facilities and equipment.[22]

VI. SUMMARY AND CONCLUSIONS

This paper is concerned with a methodology for pricing newly-privatised ports, which is applicable for long-privatised ports as well. The methodology presented here is a refinement of *ad-hoc* pricing practices. It involves identification of relevant market segments for the port, defining cost and performance indicators and calculating their comparative values for each market segment, developing and assessing *global* pricing strategies and, finally, determining specific price actions toward principal and intermediate parties in the port system. While the methodology, as described above, seems straightforward, the novelty claimed in this paper is in the tools suggested for applying it. These include: (a) the *charge-flow diagram* for calculating comparable costs in the complex, multi-layered structure of privatised ports; and (b) the *game tree* for assessing the action/reaction dynamics of pricing in the oligopolistic market setting of ports.

The paper has no conclusion other than the need for implementing the pricing methodology. It has, however, a recommendation, to make pricing strategies and related actions known, to facilitate stability and avert to the extent possible price wars.

ENDNOTES

1 A country by country review and analysis is included in a series of papers by researchers of the LSU National Ports and Waterways Inst., USA, including Hochstein and Kent (1996); Kent and Hochstein (1997).

2 The terminology and respective abbreviations used in this paper are: port = port authority, the public or quasi-public entity which controls the basic infrastructure involved in ship and cargo handling; shippers = importers/exporters and their representatives (cargo interest); lines = shipping lines, referring to ship owners and their representatives (vessel interest); operators = private contractors providing port services; stevedores = operators who specialise in ship handling; port system = all of the above-mentioned parties. The term port is also used to describe the facilities where vessels and cargoes are handled. A terminal, such as a container terminal, is part of a port.

3 Some of the data included here were modified to protect the commercial interests of the port.

4 These topics are included, among others, in the texts of Heggie (1974), Bennathan and Walters (1979), followed by Ashar (1985, 1986), Arnold (1987, 1988, 1990, 1994), MarAd (1986), Dowd (1987, 1992), The Australian Bureau of Transport and Communication Economics (1997), and Hochstein and Ashar (1994).

5 Some of the more comprehensive publications in this group include MarAd (1978), ESCAP (1989), Asian Development Bank (1990), Hochstein and Ashar (1994), Comision Ejecutiva Portuaria Autonoma (1995), Ashar (1997) and Drewry Shipping Consultants (1998).

6 The terms wharfage and dockage are used here to denote capital-related charges for the usage of facilities (rental).

7 Price discrimination based on *yield management* has been pioneered in the airline industry. Recently, it was implemented in liner shipping and, to a much lesser extent, in ports. A comprehensive review of the implementation of yield management in American Airline is provided by Smith *et al* (1992).

[8] A higher level of competition is between the entire transportation chains in which the port is a component. The ultimate competition is between delivered goods in which the entire transportation chain is a component. A discussion of the so-called 'competitive fronts' can be found in NPWI (1997, 1998).

[9] The term strategic relates to a war-like situation whereby each side exploits its relative advantages (or, its rival's disadvantages). The Random House Dictionary defines strategy as: '*generalship ... the art ... (of formulating) a series of maneuvers ... for obtaining a specific goal*.'

[10] The deficiency is specifically documented in two publications: (a) Arnold (1994), where the author quotes an *ad hoc* approach taken by ports to pricing in a section titled 'moments of clarity'; and (b) Psaraftis (1998), where the author, a former Operations Research Professor nominated chairman of a major port, complains that he is forced to take an '*approach void of sophisticated modeling*' in determining prices.

[11] A somewhat similar approach to pricing was taken by Drewry, except that the focus there was on the profitability of container terminals (Drewry Shipping Consultants 1998).

[12] Domestic move is the transfer of a box between ship and yard; transshipment is between two ships; and rehandle is between two cells on the same ship, including an intermediate staging on the dock (unloading plus loading). Shifting boxes onboard (cell-to-cell) and handling of hatch covers are *not* counted as vessel moves.

[13] It is important to note that the total cost indicator is not a system (social) cost, since it only relates to cash costs (charges) and not to opportunity costs (eg ship's time).

[14] The Port of Miami Terminal Operating Company (POMTOC) is partnership of the four main private stevedores in Miami. The Port initiated the creation of POMTOC with the intent of enhancing yard utilisation. Miami's only container terminal is located on an artificial island, with limited expansion options.

[15] Cartagena's cost figures here are slightly different than those in the previous paragraph since the comparison relates here to ship handling by rail-mounted gantry cranes while before it related to mobile (swinging) cranes.

[16] Theoretically, the differences in service level and performance can be converted to a cost equivalent, based on the *opportunity cost* to users (eg alternative usage of ship's time) and included in the so-called *generalised* (or adjusted) cost function.

[17] El Bosque had an old and low-capacity gantry, which was assumed to be equivalent to a mobile crane.

[18] Technically, this game setting is defined as a two-person (Cartagena *vs* competitors), non-constant-sum, where cooperation is not allowed, and with a 3×3 Reward Matrix. The Game Tree in Figure 8 only includes reward combinations considered plausible. A general discussion of Game Theory is available in many Operations Research textbooks (see, for example, Winston, 1991).

[19] For convenience, losses are denoted here as negative profits although, logically, an entity can lose no more than its entire worth (100%).

[20] Technically, this indicates that the game is multi-round, whereby players use past experience to forecast future behaviour, converting the response probability into a conditional one.

[21] High-Tech lines operate larger ships with sufficient volumes per hatch to take advantage of the higher productivity of shore cranes. A specialised yard refers to a yard with a computerised inventory and location control system necessary for high throughput shore cranes.

[22] This announcement and the related expectation for a 'responsible' response from rivals intend to change the game setting from non-cooperative to cooperative, resulting in a *tacit allocation of markets*, which is equivalent to a saddle point in Game Theory. Such a quasi-monopolistic setting could attract the attention of the Port Superintendent if it results in abnormal profits.

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