Chapter 40

STRUCTURE AND OPERATIONS IN THE LINER SHIPPING INDUSTRY†

H.E. HARALAMBIDES

Center for Maritime Economics and Logistics (MEL), Econometric Institute, Erasmus University Rotterdam, PO BOX 1738, 3000 DR Rotterdam, The Netherlands

1. Introduction

Shipping is a global service industry that by general acknowledgement provides the lifeline of international trade. Suffice it to say that, due to the morphology of our planet, 90% of international trade takes place by sea. Technological developments in ship design and construction, and the ensuing economies of scale of larger ships, have also promoted trade – particularly those of developing countries – by making economical the transportation of goods over long distances. This has expanded markets for raw materials and final products and has facilitated the industrialization of many countries around the world. Often, international ocean transportation and information and communication technologies are referred to as the two basic ingredients of globalization (Stiglitz, 2006).

Traditionally, the shipping industry is categorized in two major sectors (markets): the bulk shipping sector – engaged mainly in the transportation of raw materials such as oil, coal, iron ore and grains – and the liner shipping sector (involved in the transportation of final and semi-final products such as computers, textiles and a miscellany of manufacturing output).

From a market structure point of view, the two sectors are as different as they could be bulk shipping uses large and unsophisticated ships, such as tankers and bulk-carriers, to transport goods in bulk on a contract basis. The service requires minimal infrastructure, and in this respect, it resembles a taxi service whereby the contractual relation between passenger and driver (cargo owner and ship owner) expires upon the completion of the trip. The industry is highly competitive with prices (freight rates) fluctuating wildly even in the course of a single week.

† The first edition chapter was co-authored with A.W. Veenstra

Handbook of Transport Modelling, Edited by David A. Hensher and Kenneth J. Button

Modeling in bulk shipping is therefore focused on the estimation of demand and supply functions and freight rate forecasting. For a good literature review, see Haralambides et al. (2005); Veenstra (1999); Stopford (1997); Beenstock and Vergottis (1993); Wergeland (1981); and Norman (1979).

On the contrary, liner shipping is geared to the provision of regular services between specified ports, according to timetables and prices advertised well in advance (Haralambides, 2004; Jansson and Shneerson, 1987). The service is in principle open to everyone with some cargo to ship, and in this sense, it resembles a public transport service, like that of a bus or a tram. The provision of such a service – often of global coverage – requires extensive infrastructure in terms of terminals and/or cargo handling facilities, ships, equipment, and agencies. For instance, the provision of a weekly service between Europe and Southeast Asia requires investments in excess of one billion US dollars. Understandably, investments of this magnitude may, on the one hand, lead to undesirable capital concentration and, on the other, pose considerable barriers to entry for newcomers. These aspects of the industry have constituted important research areas and are briefly discussed below.

Cargo carried by liner shipping has come to be known as *general cargo*. Up to the beginning of 1960s, such cargo was transported, in various forms of packaging, such as pallets, boxes, barrels, and crates, by relatively small vessels, known as general cargo ships. These were twin-deckers and multi-deckers, i.e., ships with *holds* (cargo compartments) in a shelf-like arrangement, where goods were stowed in small pre-packaged consignments (parcels) according to destination. This was a very labor-intensive process and, often, ships were known to spend most of their time in port, waiting to load or discharge. Congestion was thus a chronic problem in many ports, raising the cost of transport and hindering the development of trade. Equally importantly, such delays in ports made trade movements erratic and unpredictable, obliging manufacturers, wholesalers, and retailers to keep large stocks. Consequently, warehousing and carrying (capital) costs were adding up to the cost of transport, making final goods more expensive and, again, hindering international trade and economic development.

This situation started to change in the nineteen sixties with the introduction of *containerization* in the trade between the United States and Europe and, subsequently, in the rest of the world. Containerization is often described as a revolution in transport. General cargo goods are now increasingly carried in steel boxes (containers) of standardized dimensions (most common is the $8 \times 8 \times 20$ feet unit known as TEU –Twenty (feet) Equivalent Unit – although containers of double this size (40 feet) are quite common mainly in North America). Perhaps one of the most important effects of containerization is that, now, containers can be packed (*stuffed*) and unpacked (*stripped*) away from the waterfront, either at the premises of the exporter (consignor) and/or the importer (consignee), or at Inland Container Depots (ICD), warehouses, and distribution centers.

Expensive and often strongly unionized port labor is thus by-passed; pressure on port space relieved; and ship time in port minimized. These developments have increased ship and port productivity and system reliability immensely, thus allowing ships to become even bigger, achieving economies of scale and low transport costs. Nowadays, containers are increasingly carried by specialized *cellular* containerships many of which able to carry more than 8000 TEUs, while designs for 10,000 or even 15,000-TEU ships are already on the drawing boards of naval architects.

At the time of writing, such a mammoth ship could cost anything in the neighborhood of 100 million US dollars and it could take up to eight of them to run a weekly service between Europe and Southeast Asia. The capital intensity of these ships – the equivalent of a jumbo jet in aviation – obliges them to limit their ports of call at each end to just a few *hub* ports or *load centers* such as Singapore, Hong Kong and Rotterdam, from where huge surges of containers are further forwarded (*feedered*) with smaller vessels to regional and local ports. Complex *hub-and-spoke* networks have thus evolved whose fine-tuning and optimization bears directly on consumer pockets.

Around the world, the port industry has invested a lot, to cope with the technological requirements of containerization. Modern container terminals – and commensurate cargo-handling equipment – have been built and new, more efficient, organizational forms (including privatization) have been adopted in an effort to speed up port operations. Operational practices have been streamlined; the element of uncertainty in cargo flows largely removed; forward planning has been facilitated; port labor regularized; and customs procedures simplified. These developments took place under the firm understanding of governments and local authorities that ports, now, constitute the most important link (node) in the overall door-to-door supply chain and thus inefficiencies (bottlenecks) in the port sector can easily whither away all benefits derived from economies of scale and scope in transportation and logistics.

By-passing the waterfront in the stuffing and stripping of containers, and thus having them ready in port to be handled by automated equipment, increased immensely the predictability and reliability of cargo movements, enabling manufacturers and traders to reduce high inventory costs through the adoption of flexible Just-in-Time and Make-to-Order production technologies. *Inter alia*, such technologies have helped manufacturers to cope with the vagaries and unpredictability of the business cycle and plan business development in a more cost effective way.

2. Optimization of liner shipping operations

Under the assumption of a certain market share (demand); the constraints of regularity and frequency; and the incessant drive to cut costs (mainly through the deployment of larger ships), liner shipping companies must optimize their operations providing solutions to a number of important problems such as: how many ships to deploy on a route? Should one serve a specific demand with few larger ships or with more smaller ones? What are the logistical requirements of the customer in this respect? What speed? At which ports to call? How should one deploy ships and containers? How to manage a fleet of empty containers and trade imbalances? Should one buy or lease containers?

Operations Research (OR) – mainly linear and integer programming algorithms – has been extensively used to give answers to such questions. For a review, see Cariou and Haralambides (2000) and Ronen (1983, 1993).

Ronen (1993) notes that, since the 1980s, the problems addressed in the literature have become more realistic, involving "actual" optimal solutions rather than approximations (in operations research the latter solutions are called *heuristics* and are rather common due to the mathematical complexity of real-world problems). He attributes this to advances in mathematical programming, facilitated by the development of inexpensive computing power.

The vessel deployment problem concerns the allocation of ships to routes within the service network of a liner operator. Examples of problems of size, mix and deployment of vessels can be found in Lane et al. (1987) (fleet size and mix) and Jaramillo and Perakis (1991) (deployment). Lane et al. attempt to determine the most cost effective size and mix of a fleet of ships on a specific route. They apply their model to the Australia-North America West Coast route. Jaramillo and Perakis construct a model that assigns a fixed fleet of ships to a given set of routes, taking into account detailed information on operating costs, cruising speeds, and frequency of departure. They present an example of 14 ships and 7 routes.

Rana and Vickson (1988) present a model for the determination of fleet size and routing of vessels. Their problem starts from an operator who contemplates adding an extra ship to his fleet. The authors are able to determine the route this additional ship should ply, and they also solve problems that include schedules of up to 10 or 20 ports. This makes their model suitable for practical purposes, although they constrain it to include only one type of container.

Jansson and Shneerson (1985) derive a transport cost function that also includes user costs (mainly inventory costs). In this way, they are able to determine the optimum ship size. Their analysis however does not address the issue of routing.

Scheduling problems deal with the assignment of departure and arrival times of ships operating on a certain route. Rana and Vickson (1991) present such a model. They point out that although scheduling is a fairly common exercise in transport, liner shipping has certain intrinsic features that make the design of scheduling models particularly difficult.

These complexities consist of, *inter alia*, the existence of combined pick-up and delivery activities; the fact that ships in a fleet can ply different routes; and the peculiarity that routes, being a string of ports, are always visited in a fixed sequence. The Rana and Vickson model extends the results of their 1988 work in the sense that the model is now able to address problems involving more than one ship. In essence, this makes their model a routing one. The scheduling issue is addressed by determining the sequence in which the different ships call at ports in the service network. They report an example that includes three ships and five ports, although they mention the possibility of applying the model to networks of 10 to 20 ports. The computational requirements, however, increase very rapidly with the number of ships. This seems to constrain the applicability of the model in liner shipping, where eight to 12 ships are commonly used on a route. Nevertheless, Rana and Vickson believe that their procedure is the surest way forward to more realistic models that can cope with more ships, and they see applications in aviation, bus and railway networks.

One of the largest cost elements in liner shipping has to do with the management of the fleet of containers. The flow of containers across the world does not coincide with the routing of containerships, because containers do not spend all their time onboard ships: they need to be picked up and delivered at inland locations, maintained, repaired or may not be needed for some time. This makes the management and optimal relocation of empty containers a separate control problem. The main objective here is to ensure that, at every location, enough empty containers are available so that all transport requests from customers can be satisfied. This problem becomes an actual and immediate one whenever, on a certain route, more cargo moves in one direction compared to the other. Such a route is known as an *unbalanced route*, or a route with *cargo imbalance*. This is the case, for instance, of the Europe-Far East route, one of the three trunk east-west routes where most of the containerized trade takes place (the other two being the transatlantic and the transpacific).

All liner companies have management systems in place to optimize the relocation of containers, but as a result of commercial sensitivities little is known on the associated models. As an exception, Gao (1994) presents a two-stage container repositioning model that determines first the size of the container fleet, and subsequently the allocation of containers in the liner service network.

3. Market structure modeling

Perhaps one of the most pronounced characteristics of liner shipping is its high fixed costs. In order to keep to its pre-advertised time-schedule, a ship must leave port regardless if it is full or not. Its costs thus become fixed, i.e., independent of the amount of cargo carried. The only variable costs are thus *Terminal Handling*

Charges (THC). Next, imagine the admittedly simplified case where, minutes before the ship sets sail, an unexpected customer arrives at the port with one container to ship. If the vessel has unfilled capacity, which is often the case in liner shipping, its operator would be tempted to take on the extra container even at a price as low as merely the extra (marginal) cargo-handling costs involved in taking the container onboard. But if this were to become common practice among carriers, competition among them could become *destructive competition*, pushing prices down to the level of short-run marginal costs. Consequently, liner services would not be sustainable in the long-run, as operators would not be able to recover costs in full, most importantly capital costs, such as depreciation allowances, for the eventual replacement of the ship.

It has thus been thought that price competition should be limited and a mechanism found to allow operators charge long-run average costs to the benefit of a sustainable, regular, frequent and reliable service, according to the requirements of demand (i.e., the customers themselves). This mechanism was found in the face of *conferences*, which are carrier coalitions, having price-setting as their main objective (Haralambides, 2004).

In the UNCTAD Code of Conduct for Liner Conferences (UNCTAD, 1975), the term *conference* or liner conference is defined as "... a group of two or more vessel operating carriers which provides international liner services for the carriage of cargo on a particular route or routes within specified geographical limits and which has an agreement or arrangement, whatever its nature, within the framework of which they operate under uniform or common freight rates and any other agreed conditions with respect to the provision of liner services."

Daniel Marx Jr. (1953) in his celebrated book defines shipping conferences, or rings, – among the earliest cartels in international trade – as "... agreements organised by shipping lines to restrict or eliminate competition, to regulate and rationalise sailing schedules and ports of call, and occasionally to arrange for the pooling of cargo, freight monies or net earnings. They generally control prices, i.e., freight rates and passenger fares. The nature of their organisation varies considerably, depending on the market structure of the trade route. Some have been conferences quite literally – informal oral conferences – but many have employed written agreements establishing a permanent body with a chairman or secretary, and containing carefully described rights and obligations of the conference membership ... "

Limitation of price competition has enabled conference members to compete on *quality of service*. A good insight into the role of the *quality* variable in liner shipping can be found in Devanney et al. (1975). These authors observe that conferences, while often being considered as monopolists, do not actually earn the corresponding monopoly profits. They explain this by pointing at the strong competition among conference members on the quality of service. When price is fixed, differentiation on quality is the only way a conference member can increase its own revenue at the cost of other members. Devanney et al. suggest that the main variable in this competition is speed: some conference members are simply able to offer quicker services or, in case of difficult circumstances such as congestion in ports and bad weather, are in a better position to maintain sailing schedules. Nowadays, quality variables are considered to be the provision of information and EDI systems; logistical services of all sorts; better coordination and integration with inland transport companies; ownership of terminals and equipment; frequency of service; geographical coverage and, in general, supply chain integration and management.

It all honesty it must be said that conferences pre-existed the *short-run marginal cost pricing* worries of carriers, and in reality they were conceived as mechanisms to protect trade (often combined with *gunpoint diplomacy*) between the metropolis and its colonies. In modern times, they have been allowed to exist, so far exempted from anti-trust legislation, on the basis of "sustainability of service" arguments like the above. Such regulatory leniency, however, has not come without the sometimes severe criticism and outcry of many *shippers* (cargo owners) who have seen price-setting; price discrimination; port, cargo and market share allocations; secrecy of conference agreements and similar restrictive business practices exercised by conferences as not promoting trade to the detriment of the consumer.

In the earlier days, conferences have been known to exercise price discrimination – the ultimate trait of monopoly pricing – according to the principle of *charging what the traffic can bear*. In brief what this means is that the carrier had the ability to assess the price elasticity of a certain cargo (or shipper) and charge each according to its (his) ability to pay. In economic jargon, price discrimination enables the carrier to extract most of *consumer surplus* for himself. Such practices, however, have become less and less common as a result, of containerization and the consequent charging of uniform rates per container. Obviously, containerization makes it increasingly difficult to justify price discrimination on the basis of an alleged need for different treatment of goods according to their particular characteristics (such as volume, stowage, cargo handling, etc.).

Price discrimination in liner shipping has been viewed both negatively and positively. First, regardless whether price discrimination is effectively exercised or not, only the potential ability of carriers to do so demonstrates a certain degree of monopoly power justifiably detested by consumers and regulators alike. However, price discrimination has also been seen positively in the sense that it has promoted trade by making possible the exportation of low value, price-sensitive commodities, many originating from developing countries. Furthermore, it has often been argued, price discrimination introduces, paradoxically, an element of competition in the sense that it attracts hit-and-run operators who, with minimal infrastructure and other overheads, "skim" the market, targeting high-value goods only, by rigorously undercutting conference prices. As a result, conferences have traditionally tried to exclude independent outsiders through a number of devices such as fighting ships (price wars), deferred rebates, loyalty agreements and so on.

Notwithstanding the above, the issue of monopoly power and the ensuing pricing strategies of conferences have constituted important research areas of market modeling in liner shipping. Whether price discrimination – that has undoubtedly been exercised by conferences – aims at profit maximization or merely at allowing low-value cargoes to be transported (to increase ship capacity utilization and/or expand geographical coverage to peripheral or otherwise *uninteresting* regions such as Africa and Latin America) still remains to be shown. Research results have not been conclusive given the inherent difficulties in measuring price elasticities of a miscellany of goods loaded at a great number of ports around the world (Sjostrom, 1992).

The issue of monopoly power has been approached through other avenues as well. A number of econometric models, using cross-section data, have been estimated with varying degrees of success. They all attempt to explain prices (tariffs) through such explanatory variables as the "unit value of the transported goods" (an indicator of price discrimination); "stowage factor" (an alleged cost indicator expressed by the volume/weight ratio of the goods); and the "total trade volume on the route" (indicating the potential for outside competition).

Several authors have presented results on such pricing models, where tariffs were regressed on the above-mentioned variables. Examples are Deakin and Seward (1973), Bryan (1974), Heaver (1973a), Shneerson (1976), Jansson and Shneerson (1987), Talley and Pope (1985), and Brooks and Button (1994). The models of the first five of these works are rather similar in terms of the selected variables. Their results are also fairly comparable and indicate that both the "unit value" and the "stowage factor" are important explanatory variables for liner tariffs.

The basic idea with these two explanatory variables is that if the "unit value" variable proves to be significant, conferences are able to discriminate on price and there is thus a considerable degree of monopoly power. If, however, the stowage factor is shown to be the most important variable, this implies that conferences compete on costs and considerable competition thus prevails in the market.

The inclusion of the "trade volume" variable has given rise to the examination of a most interesting phenomenon that has come to be known as the "inbound-outbound freight rate controversy" (Heaver, 1973b). A number of authors have observed that routes inbound usually carried different rates from routes outbound of a certain area. This was first noticed in the transatlantic route, but it appeared to exist on other routes as well. Bennathan and Walters (1969), Heaver (1973b), Devanney et al. (1975), and Byington and Olin (1983) have contributed in this area. They found that reasons lie in the commodity structure of the inbound and outbound routes and cargo imbalances, as well as in differences in the level of competition on the two legs of the route. In this respect, more competition means lower rates.

In the case of the United States and the transatlantic route, Bennathan and Walters (1969) observed a cargo imbalance favoring the outbound leg. This was of course reasonable due to the reconstruction of Europe after a ruinous WWII and the import demand this generated; the picture (and the imbalance) is the opposite nowadays. As a result, the authors argued, *tramps* (i.e., unscheduled independent ships) were sailing from the US full with bulk cargo, leaving all outbound liner cargo to the conferences. Competition from tramps was thus minimal and as a consequence tariffs on the outbound leg were higher than the inbound one (Europe–US) where more competition prevailed. This situation could be explained reasonably well by variables such as *trade volume* and number of conference and non-conference operators on the route.

In the sixties, but particularly in the 1970s, containerization virtually eliminated competition from tramps. Obviously, large company size and infrastructural requirements could not be met by the often single-ship tramping companies whose advantage was merely "flexibility." Interest in the inbound-outbound issue was thus lost together with the importance of the "stowage factor" as an explanatory variable of liner tariffs.

The demise of the *stowage factor* was illustrated in the work of Talley and Pope (1985) who obtained data similar to those of Deakin and Seward, Heaver, Bryan, and Jansson and Shneerson, but on a containerized route. They found that the stowage factor, previously an important explanatory variable, disappeared from the equation and, at the same time, the coefficient of "unit value" was much smaller than in previous results. Due to the uniform way of treating cargo in a container, these results are not difficult to understand. Brooks and Button (1994) confirm these results and suggest alternative variables that should nowadays be considered: customer type, direction of trade and type of service.

The year 2006 (the time of writing) saw the prohibition of liner shipping conferences in trades to and from Europe. The EU Council of Ministers decided to revoke Regulation 4056/86 that exempts conferences from the competition law of the Union. This, while conferences are allowed throughout Asia and when, simultaneously with the EU abolition, Singapore's newly established Competition Commission legislates in favor of conferences.

Haralambides et al. (2003) have shown this to be a wrong decision that will likely blow up in the face of the EC exactly in the same way as its infamous port package did some time ago.

The removal of *some* self-regulatory power from an industry as international as liner shipping, where no national competition law can apparently apply, will lead –with mathematical certainty – to higher prices and transport system unreliability, seriously jeopardizing global *Just-in-Time* systems of production and distribution. At the end of the day, the European citizen will again have to foot the bill of ill conceived and introvert policies that run against global European competitiveness.

4. New theoretical perspectives on liner shipping

Unlike monopoly theory, a useful concept in explaining the structure of liner shipping markets is that of *destructive competition* (see, for instance, Davies, 1990). This process –whereby competition eventually leads to the destruction of the industry – provides the basis for some new perspectives on market structure of liner shipping. These perspectives have led to new quantitative research of a nature completely different from the one discussed above. This section briefly introduces two of these perspectives, namely the *theory of contestable markets* and the *theory of the core*, and discusses the quantitative analysis that finds its basis in these theories.

4.1. The theory of contestability

The theory of contestable markets owes it origin to Baumol et al. (1982). A perfectly contestable market is characterized by two properties:

– There are no barriers to entry in the market and exit is costless;
– Incumbent operators will not react (through pricing) to new entry.

One could say that a contestable market can be entered and exited at will by anyone, while incumbent operators have no way to prevent this. The fact that this possibility exists introduces an element of competition, and although there may actually be only one active operator in the market, prices charged are not far from *social opportunity costs*. To quote Baumol, "*lack of entry can be a virtue, not a vice.*"

Davies (1986), Zerby (1988), Franck and Bunel (1991) and Shashikumar (1995) argue that liner shipping markets can accurately be described as contestable. Opposed to this claim are Pearson (1987) and Jankowski (1989a).

The main issue when it comes to the applicability of the theory of contestability in liner shipping is *entry*, especially potential entry. The type of market entry that is relevant in this context, however, is not that of new companies, these remain fairly the same over time, but the entry of ships (of incumbent companies) in a given route. These ships may be new ones, but could also be existing ones previously active in another route; and it is this possibility of shifting ships between routes that makes contestability theory so appealing for liner shipping.

Davies (1986) is the only author who offers an actual empirical analysis to substantiate the validity of contestability theory in liner shipping. He presents counts of actual entries and exits of ships on a number of liner routes and on the basis of these, he concludes that entry and exit do occur a lot. His work is heavily criticized by Pearson (1987) and Jankowski (1989a), who argue that it is not the "actual" entry that is relevant, but the *threat* of entry. Substantial entry and exit, they argue, could also point at destructive competition, which is an indication of short run marginal cost pricing rather than contestability.

The theory of contestability does not appear to offer as many possibilities for successful modeling of liner shipping as the monopoly view, but it offers a more satisfactory description of liner shipping markets. In his critique on contestability, Jankowski (1989b, 314) argues that "(..) market contestability does not explain why institutions (such as conferences) have emerged in liner shipping and not in other modes, something that limits the usefulness of the theory for policy analysis." Pirrong (1992) and Sjostrom (1989) claim that such an explanation can be provided by the *theory of the core*.

4.2. The theory of the core

A less disputed, albeit a more esoteric approach to liner shipping market structure is the Theory of the Core. Here, in short, the trading mechanism is not based on price but on exchange arrangements between agents (such as carriers and shippers) in a particular market economy. The trading process is called a *market game*. The combined *possessions* (such as vessel fleet and amount of cargo) of agents in a market game is called an *allocation*. If such an allocation is feasible and it cannot be improved by a coalition of agents, then the allocation is said to lie in the *core* of this market economy. One of the contemporary proponents of the theory is Telser (1978, 1982).

The theory of the core has been applied to liner shipping to show that this could be an example of an industry where the core is actually "empty." This means that stable liner systems cannot exist for long. Pirrong (1992, 129) states that "a core-based model effectively explains the incidence of collusion and competition in ocean shipping markets."

Sjostrom too argues that liner shipping might be characterized by an empty core, which could imply that conferences exist to "solve the problem of an empty core" (*op. cit*. 1162; see also Pirrong, 1992, 89–90). Jankowski (1989b, 315) argues similarly that conferences exist to change the structure of the market games in such a way that the outcome is more beneficial to both shippers and carriers.

The conditions for an "empty core" are inefficient entry, demand divisibility, and marginal cost indivisibility. Both Sjostrom and Pirrong argue that these conditions are met in liner shipping and they provide empirical evidence for their assertion.

By relaxing the conditions of an empty core, Sjostrom constructs a test to obtain situations where it is uncertain whether an empty core might arise or not. If the core is empty, Sjostrom assumes that a cooperation agreement will emerge. In this way, he derives a number of testable implications (*op. cit.*, 1164ff):

1. Agreements are more likely the more homogenous firms are;
2. Agreements are more likely in markets with lower price elasticity of demand;
3. Agreements are more likely if firms' capacity is large relative to market demand;
4. Agreements are more likely if the industry is in recession;
5. Agreements are more likely in industries with more variable demand or costs;
6. Agreements are less likely if there exist legal restrictions to entry.

Sjostrom compares these implications with the ones arising from monopoly theory. He finds that in the case of implications 4, 5 and 6, the two theories lead to opposite conclusions. Furthermore, on the basis of a cross-section sample of 24 conference routes, he is able to estimate only implications 2, 3, 5, and 6. Implications 1 and 4 are not testable, as the author does not have an operational definition of company "homogeneity," and his data (cross-section) is for one time-period only. The estimation results show support to the theory of the core, producing the correct predictions of the signs of the estimated coefficients.

Pirrong emphasizes the importance of costs, relative to demand, as a possible source of an empty core. His investigation thus focuses on the nature of demand and the structure of (marginal) costs. First, Pirrong asserts that demand in liner shipping is finely divisible (i.e., shippers desire the transport of small consignments) and highly variable (1992, 105, 106). He calculates ratios of parcel size to ship size and finds these to be small (0.2–5%). Furthermore, coefficients of variation of monthly shipments are considerable: demand varies by 10–20% of average shipping volume.

With regard to costs, Pirrong estimates cost functions from data of 266 voyages from North Atlantic US and Mexican ports to Europe. He distinguishes between capital costs, voyage costs and cargo handling costs, and presents evidence that voyage costs represent 35–43% of total costs. Since these costs are largely unavoidable, cost indivisibilities exist in liner shipping. Therefore, the author argues, the combination of a highly divisible demand with cost indivisibilities support the view that, even in a larger market, liner shipping may be confronted with an empty core problem (*ibid.*, 115).

5. Concluding remarks

In addition to an effort to provide a general overview of liner shipping, this chapter has focused on two types of models that have mainly occupied the attention of researchers in recent years. The first concerns models aiming at the optimization of liner shipping operations. The volume of publications here is rather limited, the reason being the confidentiality that often shrouds highly commercial information such as fleet deployment and container repositioning strategies. Still, the available literature offers a comprehensive coverage of the various optimization problems that can be found in liner shipping.

The second, and more important, type of models in liner shipping concerns market structure. The pertinent questions here –entailing significant policy implications – are the degree of capital concentration, carrier coalitions such as conferences and alliances, monopoly power and related pricing strategies. The amount and extent of work carried out in the last few decades leaves a lot to be desired. This is particularly true in the area of economic modeling of market structures and tariff setting processes. With the imminent demise of the conference system -and the monopoly theory approach – general price theory in liner shipping has come to a virtual standstill. In addition, the theory of contestable markets does not offer clear modeling opportunities, while Core Theory provides useful albeit difficult to interpret insights.

Modeling efforts have also been seriously hampered by the unavailability of time-series data of reasonable length and consistency. Most of the works cited in this chapter have employed cross-section data. Time-series modeling could, however, offer interesting insights into the market structure of liner shipping – something that cross-section modeling cannot reveal – and could also allow the construction of forecasting models (for an overview of time-series modeling in bulk shipping, see Haralambides et al., 2005). A time-series data set would at least have to contain data on fleet, tariffs, secondhand ship prices and volumes of container flows. Of these, limited information exists on the fleet of containerships and on liner tariffs. The latter are mostly published tariffs, having little or nothing to do with the "actual" prices paid for the transportation of containers nowadays. Building suitable and comprehensive data sets on liner shipping markets is one of the most important research tasks in the coming years.

A final word is due on the recent phenomenon of *global shipping alliances*. These are also coalitions of carriers but, contrarily to the route-based character and price-setting objectives of conferences, alliances are not involved in price-setting and one of their main objectives is to offer shippers global geographical coverage through cooperation, harmonization, and dovetailing of their members" operations.

Regularity and frequency of service, the two imperatives of liner shipping, combined with today's need for very large containerships, can easily lead to low capacity utilization for operators that would decide to go it alone. Alliances have thus emerged to exploit *economies of scope* among otherwise competing operators, through strategies such as the dovetailing of individual service networks; vessel sharing; slot-chartering; joint ownership and/or utilization of equipment and terminals and similar endeavors on better harmonization of operations.

With a few notable exceptions (Evangelista and Morvillo, 2000), research on the institution of shipping alliances is still in its infancy and questions on their stability, market power, degree of integration and similar concerns that permeated the discussion on conferences in the past have yet to be addressed.

References

Baumol, W.J., Panzar, J.C. and Willig, R.D. (1982) *Contestable Markets and Theory of Industry Structure*. Harcourt Brace Jovanovich, New York.

Beenstock, M. and Vergottis, A. (1993) *An Econometric Model of World Shipping*. Chapman & Hall, London.

Bennathan, E. and Walters, A.A. (1969) *The Economics of Ocean Freight Rates*. Frederick A. Praeger, New York.

Brooks. M.R. and Button, K.J. (1994) The determinants of shipping rates: a North Atlantic case study. Dalhousie University Nova Scotia, Centre of International Business Studies, Report No. 139.

Bryan, I. (1974) Regression analysis of ocean liner freight rates on some Canadian export routes. *Journal of Transport Economics and Policy* 161–173.

Byington, R. and Olin, G. (1983) An econometric analysis of freight rate disparities in US liner trades. *Applied Economics* **15**, 403–407.

Cariou, P. and Haralambides, H.E. (2000) Capacity pools in liner shipping; An allocation model for the East-West trades (Forthcoming: *International Journal of Maritime Economics*).

Davies, J.E. (1986) Competition, contestability and the liner shipping industry, *Journal of Transport Economics and Policy* **13**, 299–312.

Davies, J.E. (1990) Destructive Competition and Market Sustainability in the Liner Shipping Industry, *International Journal of Transport Economics* **27**, 227–245.

Deakin, B.M. in collaboration with Seward, T. (1973) *Shipping Conferences – A study of their origins, development and economic practises*. Cambridge University Press, Cambridge.

Devanney III. J.W., Livanos, V.M. and Stewart, R.J. (1975) Conference ratemaking and the west coast of South America, *Journal of Transport Economics and Policy* **9**, 154–177.

Evangelista P. and Morvillo, A. (2000) Cooperative strategies in international and Italian liner shipping, *International Journal of Maritime Economics* (*IJME*) **2**, 1–17.

Fox, N.R. (1992) An empirical analysis of ocean liner shipping, *International Journal of Transport Economics* **19**, 205–225.

Franck, B. and Bunel, J.-C. (1991) Contestability, competition and regulation. The case of liner shipping, *International Journal of Industrial Organisation* **9**, 141–159.

Gao, Q. (1994) An operational approach for container control in liner shipping, *Review of Logistics and Transportation* **30**, 267–282.

Haralambides, H.E., Fusilo, M., Hautau, U., Sjostrom, W. and Veenstra, A.W. (2003) *The Erasmus Report* (Contract of Services for the Assistance in Processing Public Submissions to be Received in Response of the "Consultation Paper" on the Review of Council Regulation 4056/86). Report prepared for the European Commission, Competition Directorate General.

Haralambides, H.E. (2004) Determinants of price and price stability in liner shipping. Workshop on *The Industrial Organization of Shipping and Ports*, National University of Singapore, 5–6 March 2004, Singapore (Workshop Proceedings).

Haralambides, H.E., Tsolakis, S.D. and Cridland, C. (2005) Econometric modelling of newbuilding and secondhand ship prices, in: Cullinane, K.P.B. (ed.), *Shipping Economics*, *Research in Transportation Economics*, Vol. XII, Elsevier, Amsterdam.

Heaver, T.D. (1973a) The structure of liner freight rates, *Journal of Transport Economics and Policy* **4**, 257–265.

Heaver, T.D. (1973b) The Inbound/outbound freight rate controversy. University of British Columbia, report.

Jankowski, W.B. (1989a) Competition, contestability and the liner shipping industry; a Comment, *Journal of Transport Economics and Policy*, 199–203.

Jankowski, W.B. (1989b) The development of liner shipping conferences: A game theoretical explanation, *International Journal of Transport Economics* **16**, 313–328.

Jansson, J.O. and Shneerson, D.O. (1985) A model of scheduled liner freight services: balancing inventory costs against shipowners' costs, *Review of Logistics and Transportation* **21**, 195–215.

Jansson, J.O. and Shneerson, D.O. (1987) *Liner Shipping Economics,* Chapman & Hall, London.

Jaramillo, D.I. and Perakis, A.N. (1991) Fleet deployment optimisation for liner shipping Part 2: Implementation and results, *Maritime Policy and Management* **18**, 235–262.

Lane, D.E., Heaver, T.D. and Uyeno, D. (1987) Planning and scheduling for efficiency in liner shipping. *Maritime Policy and Management*, **14**, 109–125.

Norman, V.D. (1979) *The Economics of Bulk Shipping*. Report, Institute for Shipping Research, Bergen.

Pearson, R. (1987) Some doubts on the contestability of liner shipping markets. *Maritime Policy and Management* **14**, 71–78.

Pirrong, S.G. (1992) An application of core theory to the analysis of ocean shipping markets. *The Journal of Law and Economics* **35**, 89–131.

Rana, K. and Vickson, R.G. (1988) A model and solution algorithm for optimal routing of a time-chartered containership, *Transportation Science* **22**, 83–95.

Rana, K. and Vickson, R.G. (1991) Routing container ships using Lagrangean relaxation and decomposition, *Transportation Science* **25**, 201–214.

Ronen, D. (1983) Cargo ships routing and scheduling: Survey of models and problems. *European Journal of Operational Research* **12**, 119–126.

Ronen, D. (1993) Ship scheduling: The last decade, *European Journal of Operational Research* **71**, 325–333.

Shashikumar, N. (1995) Competition and models of market structure in liner shipping, *Transport Reviews* **15**, 3–26.

Shneerson, D. (1976) The structure of liner freight rates, *Journal of Transport Economics and Policy*, 52–67.

Sjostrom, W. (1989) Collusion in ocean shipping, a test of monopoly and empty core models, *Journal of Political Economy* **97**, 1160–1179.

Sjostrom, W. (1992) Price discrimination by shipping conferences, *Logistics and Transportation Review* **28**, 207–216.

Stiglitz, J.E. (2006) *Making Globalization Work,* W.W. Norton and Company, Inc. New York.

Stopford, M. (1997) *Maritime Economics*, 2nd edn. Routledge, London.

Talley, W.K. and J.A. Pope (1985) Determinants of Liner Conference Rates under Containerization. *International Journal of Transport Economics* **12**, 145–155.

Telser, L.G. (1978) *Economic Theory and the Core*. University of Chicago Press, Chicago.

Telser, L.G. (1982) *A Theory of Efficient Cooperation and Competition*. Cambridge University Press, Cambridge.

Veenstra, A.W. (1999) *Quantitative Analysis of Shipping Markets*. PhD Thesis, Delft University Press, Delft.

Wergeland, T. (1981) *Norbulk, a simulation model for bulk market freight rates*. Report, Institute of Shipping Research, Bergen.

Zerby, J.A. (1988) Clarifying some issues relating to contestability in liner shipping and perhaps eliminating some doubts. *Maritime Policy and Management* **15**, 5–14.