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STRATEGIC ENTRY DETERRENCE: THE CASE OF OCEAN LINER SHIPPING

by

Michael G. Fusillo

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2001

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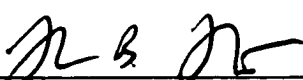
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Chair of Examining Committee

Sept. 10, 2001
Date


Executive Officer

David Gabel

Michael Grossman

Devra Golbe
Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract**STRATEGIC ENTRY DETERRENCE: THE CASE OF OCEAN LINER SHIPPING****by****Michael G. Fusillo****Advisor: Professor David Gabel**

This dissertation attempts to shed light on the proposal that firms in concentrated industries may keep excess capacity to forestall entry and/or expansion by rivals. Excess capacity can deter entry by forming expectations on the part of potential entrants that incumbents are capable of responding aggressively to threats. It is closely related to the theory of limit pricing in that excess capacity enables firms to increase output and reduce prices when potential entrants threaten. In order to make a convincing case for excess capacity as a strategic deterrent to entry, all potential sources of excess capacity in a given industry must be considered simultaneously. For example, the divisibility of demand relative to supply may create conditions for chronic excess capacity while demand that is volatile may compel incumbents to maintain a stock of excess capacity in reserve to meet peaks in demand.

Ocean liner shipping in particular appears to exhibit structural factors that can lead to excess capacity. This industry has exhibited chronic excess capacity for much of its history. Excess capacity has persisted even after the enactment of legislation that

increased incentive for firms to rationalize services. The issue that will be addressed in this dissertation is to distinguish between excess capacity that is an artifact of structural conditions of supply and demand and excess capacity that may be used to defend against opportunistic rivals. The results of a three-stage least squares model are confirmed by a subsequent random effects and fixed effects with instrumental variables model that shows some support for the entry deterrence element of excess capacity in liner shipping. Finally, a conjectural variations model is estimated to gather insight into the nature of competition in liner shipping and how it may relate to entry-detering behavior.

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I. Introduction

To make the case for the existence of excess capacity as a barrier to entry in any industry requires a thorough analysis of all of the conditions that could potentially offer alternative explanations. These may include rapid technical change or the peculiarities of supply and demand in a given market that can produce natural monopoly and/or core emptiness. Each of these concepts will be discussed later in this dissertation but for now it is important to provide an overview of the ocean liner shipping industry, its competitive environment and some of the difficulties liner shipping firms confront in their operations.

From its earliest inception in the late 19th century, profits in the ocean liner shipping industry have been unstable. Despite technological advances in ship design, carrying capacity, logistics (such as containerization), exponential growth in world demand for shipping services and a generous and ubiquitous subsidy system, the industry, as a whole, has historically failed to achieve rates of return on capital equivalent to average returns in global capital markets. A recent analysis by a private consulting firm (Drewry Shipping Consultants, 1999) reveals a ten-year average rate of return of -1.2% worldwide and -8% on the major Europe-Asia routes; this, despite a double-digit increase in demand and a 61% share of world sea-borne trade by value. In part, the poor profitability of the industry over time can be explained by operating variables that can produce highly volatile revenues and costs: seasonal trade flows, trade imbalances, fixed schedules, high capital costs, vertical restraints at sea ports, a diverse customer and product base, and high administrative overhead. Moreover, the industry is subject to the

whims of the weather, accidents at sea, mechanical breakdowns, and exogenous shocks to variables such as the cost of fuel, the business cycle and environmental regulation.

The above cannot account satisfactorily for liner shipping's entire history of poor profitability. The remainder of the explanation must come from a careful analysis of the microeconomics of the industry itself. Throughout its history, ocean liner shipping has been considered an industry in which unfettered competition fails to achieve a stable and efficient market. Instead, the nature of the service provided brings about, in the absence of regulatory intervention, instability in supply with adverse consequences for international trade. In particular, market failure in liner shipping manifests itself in the form of significant excess capacity relative to demand. There are three likely reasons why this is so, none of which are mutually exclusive. First, liner shipping retains characteristics that tend towards generally accepted criterion for natural monopoly. The most important of these is a high fixed to variable cost ratio brought about by rigid scheduling requirements. A viable liner transport service in a particular trade market requires not just one ship but multiple ships sailing at regular intervals. Second is the status of the competitive core. In markets lacking such a core, competition will often be destructive and socially wasteful.¹ Characteristics of liner shipping markets that give credence to this line of thought include highly divisible demand, indivisible supply and severe trade imbalances, all of which tend to preclude an efficient match of supply with demand. In markets lacking a core, there is never an efficient matching of demand and

¹ The term "destructive competition" is used often in this dissertation to describe a condition that is undesirable for both incumbent firms, because they are prevented from earning normal rates of return and consumers, because as incumbent firms fail, consumer choice is reduced. The end result is a loss of total surplus.

supply. Competition will be destructive and socially wasteful. Third, under the somewhat controversial assumption of zero sunk costs or perfect capital mobility, there exists some evidence that ocean liner shipping markets are contestable. In a contestable market, price is equal to marginal cost but may not necessarily be sufficient to cover fixed costs.

Under normal circumstances, an industry that is a natural monopoly and/or has an empty core is a candidate for an effective regulatory regime that can secure a stable and efficient outcome. Yet, because of the global nature of production, and because liner shipping holds significant and positive externalities, including geopolitical advantages that accrue to national governments that actively establish and operate a viable domestic maritime fleet, such a regulatory body does not exist. The lack of effective oversight is particularly troublesome with respect to state subsidy and entry, which has contributed to the persistent problem of excess capacity.² Subsidies may be, at least in part, behind the third feature discussed, that is, the proposal that liner shipping markets are contestable, which could be a central factor in the inability of operators to cover fixed costs.

To get a sense of the difficulties involved in operating a viable liner shipping firm, it may be of use to contrast ocean liner shipping markets with the bulk shipping market, often referred to as the charter market or “tramp steamer” market. Market structure is not an issue for these services. Their very different demand and supply dynamics give them characteristics that are closer to perfect competition. Bulk shippers operate primarily as vessel charters, carrying cargoes only when and where they are required. In general, a

² State assistance was instrumental to the rapid development of the maritime fleets of less developed countries and the communist bloc after World War II. See Sletmo and Williams (1981) for a discussion of the effects of state subsidy on fleet development in these regions.

shipper in this market will sign a contract with a ship operator through a ship broker to carry a specific cargo on a particular trade route. These markets tend to be in stable, well-established trade lanes that tie raw materials producers to industrial processing centers. The cargo tends to be homogenous in nature, i.e., ore and other raw industrial materials, although it can occasionally be containerized in direct competition with liner carriers. The volume to be shipped in the bulk trades is typically known far in advance, allowing the operator to deploy the most cost efficient size and type of vessel. In these markets, there are fewer commodities, shippers and contracts to be negotiated, each of which increases the flexibility of capacity choice and helps to reduce uncertainty in setting freight rates. This flexibility of capacity is the principal advantage that bulk traders hold over the liner trades. Because they are only called upon as needed and generally deploy capacity only after contract volume is sufficient to guarantee a return, they are in a secure position to exploit economies of scale inherent in ocean shipping. Consequently, even as bulk vessels have typically been much larger than vessels serving the liner trades, capacity utilization is generally higher, and as such, bulk carriers are more able to achieve the load factors that guarantee a positive profit on every voyage.

In contrast to the bulk or tramp steamer markets, ocean liner shipping is a regularly scheduled, committed transport service. Compared to bulk shipping markets, liner trade patterns are fluid and are driven by complex macro-economic relationships among trading partners. Because of this fluidity, the choice of capacity is inherently risky. In order to have sufficient capacity available to cover spikes in demand and trade imbalances, liner operators, fearing losses in market share to opportunistic entrants and

rivals, are likely to err on the side of over-capacity. This will tend to keep fixed costs high, freight rates low and profits down.

Unlike the bulk trades, the composition of liner cargoes is extremely diverse. It ranges from low-value raw materials to finished consumer goods and perishable products. Even though containerization has standardized the equipment required to move these goods efficiently by sea, each commodity retains its own particular demand elasticity, which makes establishing a proper freight rate for each a very uncertain undertaking. For example, the price to transport a ton of waste paper is very different from the price to transport a ton of stereo equipment.³ With hundreds of commodities to consider, however, operators are unlikely to get these prices right every time. Liner firms operating within “conferences”⁴ on some routes have taken steps recently to simplify their tariff structure by grouping commodities into several different categories. While this practice reduces the transaction costs for both shipper and carrier, it may also neutralize one of the principal advantages of liner shipping’s antitrust immunity (the ability to price discriminate). This is because it leaves open the possibility that prices of commodities within the broader classification may not be reflective of the value of the service. This is particularly troublesome if the conference faces significant non-conference competition, or potential competition that prices its service based on a higher level of commodity

³ Under antitrust immunity, liner carriers are permitted to price discriminate by commodity. Higher value goods tend to have a lower elasticity of demand for transport and as such they are charged a higher fee than low value commodities.

⁴ Ocean liner “conferences” are consortiums of firms operating in a particular market under antitrust immunity. They are an instrumental part of this dissertation and will be discussed in detail in later sections.

detail. In this case, value of service pricing is unworkable since it invites “cutthroat” competition from non-conference carriers.

The purpose of this dissertation is to quantify the extent to which if any strategic excess capacity influences the chronic and persistent levels of excess capacity, and hence low profitability, in liner shipping. In order to present a coherent argument for strategic excess capacity, both theoretically and econometrically, other sources of excess capacity must be considered simultaneously. There are four potential sources of over-capacity in liner shipping markets that will be examined, none of which are mutually exclusive. First is the theory of natural monopoly. If liner shipping tends to natural monopoly then under conditions of relatively free entry, brought about in part by generous government subsidy systems, incumbent carriers will be unable to sustain sufficient prices to guarantee positive profits over time. In a natural monopoly market it is more efficient, from a social welfare standpoint, for a single firm to produce output than for more than one to do so. But subsidies encourage entry and overbuilding, which if not accommodated, brings about excess capacity, lower freight rates and reduced profits. The second source relates to the theory of the core. Liner shipping’s particular conditions of demand, supply and cost tend to preclude the efficient matching of supply with demand. In these types of markets the core is said to be empty and absent the ability to form cooperative agreements either among suppliers, demanders or between suppliers and demanders, excess capacity is likely to be endemic. The third potential source of excess capacity arises from a technical contradiction in the theory of contestable markets. Although a market may meet criterion for contestability from a structural point of view, incumbent firms may find it to their advantage to erect artificial barriers to entry, including building excess capacity, to

protect their incumbency. Finally, rapid technological change, which in liner shipping implies larger and faster ships, can cause short-term excess capacity if the timing of its introduction is before demand conditions require it. Moreover, if liner shipping can truly be classified as a decreasing cost industry, then the addition of ever larger ships to capture those economies in an environment of unfettered competition can easily bring about prolonged periods of excess capacity and consequently low freight rates and profits.

What follows in this paper is first a brief overview of the economics of liner shipping; its history, technology, and market structure. Second, the conditions under which economists generally agree that markets will fail to produce a competitive outcome are discussed as they relate to liner shipping. Third, the theories of natural monopoly, contestable markets, the theory of the core, and technical change are discussed as they relate to liner shipping. Finally, an econometric model is developed and estimated to summarize and discern how the above conditions may influence carriers to over-invest in capacity which, because it has a depressing effect on freight rates, collectively drives down industry profits. Finally, a conjectural variations model is subsequently estimated to provide further insight into the competitive behavior of incumbent carriers. A discussion of the results follows as they relate to policy recommendations for the liner shipping industry.

II. Liner Shipping, Antitrust Immunity and the Liner Conference System

Liner shipping is a regularly scheduled ocean transport service where suppliers pre-commit to provide a given level of service frequency on a given trade lane. Liner

shipping services made their debut in British-Far East trades early in the 1870's when the introduction of faster and more reliable steamships made providing a regular service on long routes feasible. Improvement in communications was another instrumental element of the service since it facilitated overseas sales, and the opening of the Suez canal in 1869 greatly reduced the time and risk of providing regular global service.⁵ In a liner service, the supplier first announces a particular service and schedule and then must adhere to that service for the pre-announced time period. Supplier capacity is thus fixed by commitment since the service cannot be suspended during periods of low demand without incurring penalties from customers.

Because capacity is fixed and because the fixed costs of that capacity are a large portion of total costs, liner shipping is subject to fierce price competition since, in general, the marginal cost of handling additional freight is less than the incremental revenue. Hence the major objective of the supplier is to maximize capacity utilization on every voyage. In addition, the early liner services were by and large undifferentiated, either in the product or geographic market. As a result, competition in the early days of the industry led to destructive price wars that threatened the viability of the industry itself.

This outcome was not unlike several other capital-intensive industries that emerged during the late 19th century. Competition in railroads, steel, etc., was often self-destructive, producing unstable supply with negative consequences for social welfare. Government regulation of early industry was a means of maintaining supplier stability and thus reducing deadweight loss associated with underserved consumer demand or monopolization of the industry by one or a few firms behaving collusively. Kolko (1965)

⁵ See Stopford (1997) chapter 10 for a brief overview and history of liner shipping.

describes the early regulation of railroads, for example, as being welcomed by the industry as a means of managing competition rather than seeing regulation as a threat to profits.

The early liner shipping industry also suffered from cutthroat and destructive competition. As in railroads, this competition arose from a rapid expansion of the industry and a plethora of route choices that could be offered to shippers by the carriers. Competition between carriers still employing sail-powered vessels and carriers using steam power was particularly fierce. For example, the route to/from England and Calcutta was shortened considerably after the completion of the Suez Canal. Unpredictable wind conditions, however, made the canal unsuitable for sail powered vessels, which were forced to continue using the longer route around the Cape of Good Hope. Sail operators responded by cutting their freight rates sufficiently to maintain their presence in the market. The steam ship operators followed suit and a fierce rate war ensued that threatened to erase the efficiency gains made by the development of steam ships.⁶

Since the reduced efficiency of liner shipping could have disruptive effects on the world trading system, governments in Europe, Canada and the United States sought a means to minimize the economic damage caused by severe price competition. An obvious means of achieving market stability was to encourage carriers to form cooperative rate setting agreements, which came to be known as liner shipping conferences. Although not

⁶ Ibid.

strictly cartels, there is strong evidence that conferences behaved as such for much of their history.⁷

Liner shipping conferences have been in existence in various configurations since 1875 when British carriers serving the United Kingdom - Calcutta trade formed the first collective rate-setting agreement. This trade suffered from all of the structural problems associated with operating a regularly scheduled liner service. Seasonal trade flows and severe trade imbalances promoted over-building, and along with aggressive pricing behavior industry-wide profits were ultimately driven down. The newly formed conference agreement was immediately successful in reigning in this destructive competition, prompting other carriers serving British trades to form their own agreements. The newly formed consortia behaved in many ways like a cartel. They fixed prices among their members, imposed capacity restrictions to maintain those prices and compelled members to sail on a scheduled date regardless of whether or not the ship had a full cargo. Not all carriers were welcomed by the conference and there remained stiff competition from independent operators. To control this potential competition, conferences developed the "loyalty contract" or deferred rebate in 1877.⁸ In a loyalty contract, the shipper posts a bond with the carrier in exchange for particular service guarantees and freight rates. The bond would be redeemed only after a pre-specified interval. If the shipper went outside of the conference during that period, he would forfeit the rebate. The policy is similar to today's 'frequent flyer miles' offered by several commercial airlines. The effectiveness of loyalty contracts was recognized immediately

⁷ See Podolny and Morton (1999) and Morton (1996).

⁸ See Kendall (1983).

and they quickly became a central feature of liner conferences. Loyalty contracts survived a legal challenge by the Mogul Line in 1885 which, because it did not offer a full compliment of services for the whole year, was denied membership in the Far East Freight Conference (FEFC), a consortium of carriers serving the British - China trade. When the FEFC refused to pay rebates to merchants who had used Mogul vessels, Mogul sought an injunction to stop the rebate policy but was denied in the British courts.⁹

The liner conference system, including loyalty contracts, also survived a 1909 inquiry by the British Royal Commission on Shipping Rings. While the Royal Commission determined that conferences did constitute limited monopolies, they also concluded that the economic rents accruing to carriers via price-fixing rings was outweighed by the social and geopolitical benefits of maintaining stable and reliable ocean transport to facilitate Britain's trade.

Conferences gradually gained favor in the rest of Europe and the United States as a suitable means of managing the difficult competitive conditions in the liner shipping industry. The United States Shipping Act of 1916 officially sanctioned conferences and granted them immunity from the Sherman Act. Despite a series of price wars brought about between independent lines and conference carriers, the conference system as it stood in its earliest incarnation prevailed worldwide until the mid-1980s.

The conference system from 1916 to the 1980s, was however, an imperfect means of allocating the surplus created by global trade. Competition between conference carriers and independent operators during the years roughly between 1965 and the early 1980s were particularly difficult. The advent of containerization during this time

⁹ See Stopford,(1997) chapter 10.

drastically changed the way ocean liner shipping firms conducted their operations.¹⁰

Instead of loading and unloading goods at dockside, a labor intensive and costly link in the service, containerization allowed goods to be loaded in trailers far away from the port by either the manufacturers themselves or by third-party freight forwarders. The trailers or containers could then be trucked or railed to the seaport, then loaded by specialized cranes aboard vessels designed specifically to carry containers. Containerization virtually eliminated costly bottlenecks at ports and permitted carriers to more fully exploit available economies of scale. Containerization made obsolete traditional liner vessels and replaced them with more efficient and less labor intensive container ships. A single container ship can replace between four and five traditional liner vessels.¹¹

Technological change reduced the costs of shipping, but it also stimulated entry by subsidized independent lines on a large scale, particularly from less-developed countries (LDCs) and the socialist block. Part of the problem of entry in liner shipping is a function of uneconomic incentives (externalities) that compel nations, particularly in the developing world, to promote their own domestic maritime industry. Before World War II, much of the developing world was still under the domination of European governments, and liner firms were almost exclusively of European or North American origin. When LDCs began gaining in their independence in the 1950s and 1960s, one of their policy objectives was to establish a maritime trade industry to both increase geopolitical advantage and to partially extract economic rents generated by increased

¹⁰ Malcolm Maclean, an owner/operator of an east coast trucking firm that eventually became the largest U.S. liner carrier is credited with inventing and first implementing containerization in the late 1950s by driving his truck trailers onto the deck of a cargo vessel using a specially designed ramp.

¹¹ According to Frank and Bunel (1991). A traditional liner vessel was usually built around several decks that were arranged to carry various types of cargo depending on what trade lanes the ship was meant to serve.

world trade.¹² Demands for access to maritime markets led the United Nations Commission on Trade and Development to establish the “liner code of conduct” in 1973, the first global policy recommendation on how liner shipping conferences should operate, and the first attempt to establish an international regulatory body to oversee competition in maritime transport. The Code fully embraced the conference system as a means of stabilizing liner services and providing a level playing field for LDCs desiring to establish their own national maritime fleets. Central to the Code was the 40-40-20 rule. This provision stated that at least 40% of cargo revenues should be reserved for the national carriers of the trading partners while 20% may be reserved for third party operators. Third party operators would be permitted to join the conference on a particular route only if their entry did not cause excess capacity. The criterion for joining would thus be based on demand conditions or conditions for future growth. Most OECD countries remain opposed to the code, though some have made concessions in deference to it. The code’s lack of general support among OECD members prompted some LDCs to impose cargo reservation policies independently of the U.N. Argentina, Brazil, Venezuela and the Philippines each began implementation of cargo reservation policies in the early 1970s. Ironically, the United States would have gained considerable market share through the Code since its disadvantages in work restrictions and manning costs keeps market share for United States flag carriers significantly below the 40% permitted by the code.

Moreover, the reluctance of incumbent carriers to scrap vessels still in working order meant that the problem of excess capacity, already an inherent feature of liner shipping, was made much worse. Excess capacity created pricing pressures that the liner

¹² White (1986).

conference system proved unable to manage. Many liner firms were unable to survive in the new environment, and the industry became increasingly concentrated.

The effect of containerization on U.S. flag carriers was particularly grim. In 1960, there were 4,059 U.S. flag ships of 24,837,069 gross tons engaged in either U.S. coastal or deep sea trades. By 1979, the number of ships had risen to 5,088, but the tonnage had dropped to 17,542,220.¹³ The shrinking average size of U.S. flag vessels suggested a much weaker presence for U.S. carriers in the deep sea trades than in the coastal and inland waterways where cabotage laws offered protection from foreign competition.¹⁴

Containerization was not the only challenge to U.S. carriers. During the 1960s, a series of court decisions that produced modifications of the 1916 Shipping Act served to gradually erode liner carriers' antitrust immunity.¹⁵ In 1961, an act was passed that added a requirement that gave the Federal Maritime Commission (FMC) the power to disapprove any agreement between carriers that was "contrary to the public interest." The public interest standard was strengthened in the *Svenska*¹⁶ decision by the U.S. Supreme Court in 1968 and consequently led to a narrowing of liner shipping's antitrust immunity.

The combination of weakened antitrust immunity and significant new competition brought about by rapid technical change had a large negative effect on the U.S. shipping lines. Their numbers dwindled steadily and by the mid-1990s there were just a few American flag carriers left. Concern grew in the United States federal government that the

¹³ Sea Trade Yearbook, 1980, cited in Frankel (1982).

¹⁴ Cabotage comes from the French and relates to coastal trades. The Jones Act, enacted in 1920 is the United States' primary law governing coastal trades. It prohibits foreign carriers from engaging in any U.S. domestic trade including those between the mainland and Alaska, Hawaii, Puerto Rico, or other U.S. territories and possessions.

¹⁵ White (1988).

¹⁶ Federal Maritime Commission v. Aktiebolaget Svenska Amerika Linien, 390 U.S. 238 (1968).

American merchant marine was in danger of disappearing, and along with it, a significant weakening of its transport capabilities in case of “national emergency.” In Europe there were similar concerns, and by the early 1980s there was legislative action on both sides of the Atlantic.

The early 1980’s witnessed a wave of transport industry deregulation in the United States. Trucking, rail and airlines each underwent a process of deregulation. In general, deregulation was intended to provide more freedom in pricing, entry and cooperation among industry players. In large part, deregulation of these industries has been arguably successful. Consequently, it is tempting to apply the same free market logic to ocean liner shipping, which retains several characteristics similar to the above three industries. However, despite definite similarities, such as fixed and committed scheduling, network effects and high fixed costs relative to variable costs, the comparison of liner shipping to rail, trucking or airlines would be imperfect. In trucking, airlines and rail, capacity is far more flexible than in ocean liner shipping. Compared to container ships of minimum efficient scale, the capacity of a truck and an airplane is small relative to demand. This is not true for ocean liners, which must contend with the requirements of many small shippers (relative to efficient capacity) to fill their vessels. In rail transport, the operator has the option of shortening or lengthening his train to more efficiently match supply with demand. In liner shipping this is obviously impossible. In a committed liner service, a carrier’s ships must sail at their regularly scheduled intervals regardless of the demand at any particular point in time. Moreover, liner shipping carries with it a host of positive externalities, including geopolitical advantages that often prove too tempting for politicians to ignore. Their chronic intervention necessarily reduces the

influence of the free market on the competitive dynamics of the industry. Excess capacity is therefore a more serious characteristic in liner shipping than in other transport industries, and is one reason why the application of the same model of deregulation as has been applied in rail, trucking and airlines would likely invite even more instability. The early history of destructive competition in liner shipping provides support for this view.

By the 1970s it was clear from the decline of U.S. flag shipping companies that some form of policy intervention was necessary. There were two significant pieces of legislation to come about as a result of the decline. The Controlled Carrier Act of 1978 was intended to limit the damage done to U.S. firms by third country or non-conference competition. It provided the FMC with the authority to prohibit third country carriers from applying freight rates “that are below a level that is just and reasonable.” The second piece of legislation, into which the 1978 legislation was incorporated, was the Merchant Shipping Act of 1984. Rather than dismantling the conference system entirely and allowing what had in the past proven to be destructive, unfettered competition, the 1984 legislation was instead intended to preserve and even strengthen the conference system while simultaneously moderating its ability to behave anti-competitively. Specifically, its objectives were:

- 1) to develop and maintain an efficient ocean transportation system through commercial means with minimum government involvement in order to serve the needs of United States foreign commerce;
- 2) to foster reliable and responsible service by ocean common carriers and conferences;

- 3) to assure ocean transportation rates and practices for United States exporters and importers that are internationally competitive, and which are not unjustly discriminatory;
- 4) to harmonize United States shipping practices with those of its major trading partners;
- 5) to permit cooperation among carriers and rationalization of service;
- 6) To facilitate efficient and timely regulation by a single Federal agency of the various aspects of international liner shipping responsive to the growth of ocean commerce and international developments affecting that commerce.¹⁷

Arguably, the most important provision in the 1984 legislation was the easing of conditions for entry. While it preserved antitrust immunity, it also prohibited loyalty contracts for any carrier serving a United States trade lane. "Closed conferences" i.e., conferences that restricted membership, were outlawed and new restrictions were imposed on the conference's abilities to fix prices or limit capacity by requiring that these actions be filed with the FMC. The FMC was then charged with scrutinizing the actions for anti-competitive elements. Aside from the requirement to permit open conferences, the most important of these restrictions was the demand that the conference rules be amended to allow individual members the freedom to pursue independent pricing and capacity deployment actions without fear of reprisal. Prior to the 1984 Act, conference governing bodies could impose strict fines or other sanctions on members who deviated

¹⁷ See Frankel (1982) for a thorough history of government intervention in the liner shipping industry. The Shipping Act of 1984 was passed in that year but had been under consideration by government regulators for several years prior, during which time Frankel wrote his book on maritime policy.

from uniform pricing. Another major provision of the Act clarified the ability of carriers to negotiate inter-modal rates with U.S. overland transportation firms.¹⁸ This provided liner firms the opportunity to extend their services inland and take fuller advantage of containerization. Finally, conference carriers on United States trade lanes were compelled to file all of their rates with the Federal Maritime Commission, which subsequently used the information to monitor potential rules infractions. In Europe, Canada, and Australia, the authorities took a similar view of the system. They left deferred rebates alone, but imposed other restrictions similar to those imposed by the United States that seriously weakened conferences' ability to manage pricing. By permitting and encouraging the existence of conferences, the legislation did not deny that competitive conditions required some form of collusive action on the part of suppliers. Instead it sought to strike a balance between the need to maintain viable liner services and the needs of shippers to move freight at the lowest possible prices.

But instead of strengthening the antitrust immunity of conferences, the 1984 legislation diminished the market power of conference carriers and ultimately contributed to a further erosion of the stability of the liner transport system. The allowance for independent action was particularly burdensome. As a result of this provision, intra-conference competition intensified, particularly during economic downturns when pricing discipline is more likely to break down. A recent study by Clyde and Reitzes (1998) reveals just how weak conferences had become in the post-1984 era. They found that the post-1984 market share of conferences on two United States trade routes bore no

¹⁸ Inter-modal refers to the relatively seamless and cost-saving method of transferring cargo from ship to truck to rail, not necessarily in that order. Inter-modal equipment is highly specialized with globally standardized dimensions.

statistical relationship with freight rates. Only when their model controlled for service contracts did conference market share exert a positive influence on freight rates.¹⁹ In contrast, they found that overall market concentration exerted a positive influence on freight rates, suggesting that tacit collusion among both independent operators and conference lines is as much or more of an influence than price-fixing or market-sharing agreements. What this suggests is that the post-1984 liner conferences possessed only limited market power. Whether their weakness stems from intra-conference competition or from independent operators, their ability to impose their will on the market through coordinated action is suspect. The issue of just how collusive the conferences are has implications for the problem of excess capacity. This will be discussed in more depth in a later section of this dissertation.

There is also a question regarding the extent of market power wielded by conferences prior to the 1984 Shipping Act and even prior to the advent of containerization. Conferences, like any other cartel, were never able to completely control the pricing decisions of their members. Although detection has historically never been difficult, particularly with the onset of the information age, cheating has always been a threat to the stability of conference pricing. Various enforcement mechanisms have been imposed over the history of the liner conferences to keep members' pricing behavior in line with conference objectives. In its early stages, personal relationships among executives, particularly in the United Kingdom, served as the main enforcement mechanism. For example, Podolny and Morton (1999) found that social status was an

¹⁹ Service contracts generally guarantee the carrier a particular level of cargo volume over time in exchange for assurances of vessel space and timely deliveries. Before the passage of the Ocean Shipping Reform Act of 1998 (OSRA), these contracts were available for public viewing.

important factor in the success of a potential entrant into the British liner trades during the period between 1879 and 1929. Using historical data on British shipping firms, they found that a potential entrant was 40% less likely to trigger a price war if he had high social status among his peers. This suggests that long-term social restraints had economic significance and took precedence over short-term profits in the pricing decisions of conference members. These restraints served to prevent members from undercutting their conference partners, which would invite social sanctions and affected the violator's future business opportunities. If wealth is a proxy for "high social status," then Morton's 1996 study of British shipping conferences during the same period gives credence to this argument. She found that potential entrants who were "weak," i.e., those with less financial resources or experience in the industry (presumably fewer personal relationships within the industry) were more likely to trigger a price war upon entry. The structure of the modern liner industry is unlikely to fit the above characterization. The industry is too large and the national composition of conference members too diverse to bind strategic economic behavior by means of social relationships. Morton finds little evidence of cheating during her study period. This is partially a result of the use of independent sales agents in Britain who would be aware of any price decreases and would subsequently be likely to pass this information along to other carriers. Modern liner firms generally retain their own sales forces, although as of late the influence of third-party freight forwarders has been increasing.

The effects of the 1984 legislation were not all bad for the industry. Because the 1984 legislation weakened the conference's ability to fix prices, conference carriers redirected efforts towards reducing unit costs. Consequently, there was a wave of

technological change in container ship design and construction after 1984. Ships constructed in this period were larger, faster and more fuel-efficient than their predecessors, as the pursuit of economies of scale became paramount. Carriers also sought to differentiate themselves along the lines of speed and reliability of service. Innovations in refrigeration opened the way for liners to carry higher margin perishable products such as produce, wines, seafood, and so on. At the same time, carriers began increasing their use of joint-service contracts and vessel sharing agreements designed to rationalize costly excess capacity.²⁰ Large scale mergers and global alliances similar to the international airline industry became more commonplace, and there has also been a major effort in some trade lanes to vertically integrate operations by taking financial stakes in land-side infrastructure like sea ports, and by providing door-to-door logistics services. These efforts have met with varying degrees of success for carriers. While some rate stability was reestablished in a few trade lanes, rates of return on capital nonetheless remained stagnant throughout the 1990s, as competition forced unit cost savings to be almost entirely passed along to shippers whose freight rates had never been lower and service options never more numerous.²¹

Conferences are not the only means by which carriers can cooperate. In 1994, some of the major global carriers, i.e. those carriers serving a multitude of trade routes, began forming strategic alliances. These differ from rate setting conferences in that they are an arrangement specifically intended to rationalize capacity rather than set freight

²⁰ In a joint-service contract or vessel sharing agreement, two or more carriers agree to share their vessels and other services with one another. This serves to rationalize capacity and it gives carriers an opportunity to serve a trade lane without actually deploying its own vessels.

²¹ World total freight costs have fallen from 6.6% of total import value in 1980 to 5.2% in 1997. See UNCTAD Review of Maritime Transport, 1999.

rates. At their onset, large global carriers for the purpose of rationalizing capital such as vessel space, containers, and marine terminal equipment formed strategic alliances. More recently, there has been an increase in shared information technology and inland facilities.²² Strategic alliance agreements vary by trade lane, but in general their benefits go beyond capacity rationalization. Their purposes are to improve flexibility in response to ongoing changes in world-wide cargo flows, improve the ability to provide better service, increase the number of port calls without necessarily deploying more vessels, minimize transshipment points and consequently reduce the reliance on feeder vessels.²³ Additionally, alliances facilitate improved sailing frequency, better transit times and service quality, increased risk sharing among members and improvements in the coordination of new vessel purchases. Alliances can exist on a smaller scale as well, in the form of vessel or space sharing agreements. Unlike conference agreements, alliances leave all pricing decisions up to individual firms.

On their surface, alliances appear to be a reasonable approach to managing competition in liner shipping markets. For carriers, they may help to reduce excess capacity and thus economize on fixed costs. For shippers, they provide a more extensive transport network, which improves service quality. In terms of social welfare, however, alliances may not be the best response to unstable competition. With an emphasis on the airline industry, Chen and Ross (2000) find that although alliances may not lessen competition, and may even improve efficiency in the existing market, they may also act as a barrier to entry to an even more efficient newcomer. They find this to be the case if

²² See Federal Maritime Commission (1996).

²³ Feeder vessels are ships that relay cargo from ports that are inaccessible to larger container ships.

entrants can in effect be “bribed” to accept shared facilities rather than building newer, more efficient facilities. Their model reveals a loss in consumer surplus regardless of whether the alliance members serve separate or identical markets.

Indirectly, alliances, like rate setting conferences, can reduce potential competition by taking advantage of liner shipping’s network characteristics. Rather than set prices that make entry unattractive, the pooled financial resources of alliances can be used to outbid non-alliance carriers and potential entrants in the purchase and leasing of limited port facilities. Ports are essentially landlords that rent limited berthing space and acreage for storage and drayage (loading and unloading) to carriers and independent stevedoring firms.²⁴ If alliance members exclusively occupy that limited space, then entrants can be effectively shut out of serving that particular port. Alliances can also reduce competition among existing members because sharing equipment makes carriers increasingly interdependent. The incentive to undercut partners on freight rates is reduced since the retaliation it would invite would raise the price cutter’s costs by excluding him from the cost sharing alliance.

The emerging prevalence of global alliances and vessel sharing agreements as a means of managing liner shipping competition can easily be seen in the data for U.S. trades. According to PIERS (Port Import Export Reporting Service), on the inbound lanes, in 1991 there were 1.5 individual steam ship lines on average transporting a cargo aboard a single vessel. By 1999 this number had climbed to 2.1, a 40% increase over the eight year period. As might be expected, the increase in vessel sharing was more

²⁴ Stevedoring refers to the loading and unloading of a vessel. Stevedoring for a large container vessel can be an arduous task since containers of different weight must be distributed on the ship to ensure its smooth operation at sea.

pronounced on the longer trade routes. Inbound from Northeast Asia, a region defined as China, Japan, Taiwan, Hong Kong and Korea, the average number of individual ship lines aboard a single vessel was 1.6 in 1991 and 2.5 in 1999, a 56% increase. Liners serving North Europe, defined as all of Scandinavia, Germany, France, Belgium, the United Kingdom, the Netherlands and parts of Eastern Europe including Russia, were even more cooperative. Their numbers were 2.7 in 1992 and 3.8 in 1999, a 41% increase. Vessel sharing is also popular on the shorter so called north-south routes where the fleet size requirements are far less substantial than longer east-west routes. From Central America, the numbers were 1.0 in 1991 and 1.7 in 1999.

Increased carrier cooperation outside the conference system after 1984 provided some measure of improvement in the profitability of liner shipping, at least for the larger, global carriers. However, the average rate of return remained below global averages throughout the late 1980s and 1990s.²⁵ Despite opportunities for capacity rationalization created by increased cooperation, excess capacity has remained an impediment to further progress. Specifically, the prohibition of loyalty contracts significantly eased the conditions for independent entry. Low cost entrants, especially those in the developing world that tended to operate under generous state subsidy programs, were able to gain footholds in U.S. trade lanes. Korean, Brazilian and Chinese carriers have been particularly successful in penetrating the U.S. liner market. The new entry is partly responsible for the problems of excess capacity and has had a depressing effect on freight rates. United States flag liner carriers were particularly vulnerable to the 1984 legislation since in addition to the difficult regulatory regime, they carried the added burden of

²⁵ Drewry Shipping Consultants, 1996.

significantly higher manning costs than their rivals in Asia and Europe. By the late 1980s the number of subsidized United States flag carriers was down to just four from the 15 that operated during the 1970s.²⁶

In part, to restore some stability to the U.S. liner markets and to restore some market power to its domestic carriers, the United States passed the Ocean Shipping Reform Act (OSRA) in 1998, which became effective in May of 1999. The new legislation amends the 1984 Shipping Act by allowing carriers serving United States trades to enter into long-term confidential and volume-based contract agreements with shippers. It is too soon to gauge the long-term effects of this policy change, but while it has certainly given more of a theoretical advantage to individual incumbent firms, the practical effects on liner conferences have been negative. Already, the Trans-Atlantic Conference Agreement (TACA), a consortium of liners serving the U.S.-North Europe trade has all but disbanded with little chance of it being reconstituted into an effective rate-setting conference in future.²⁷ This conference previously had an excellent record of cohesion among its members, resulting in relatively stable freight rates and service. In the Trans-Pacific, only discussion agreements are currently in effect.²⁸ In the South America trades, both the Inter-American Freight Conference, serving the East Coast of the United States and the East Coast of South America, and the West Coast South America Discussion Agreement, linking all United States ports with the West Coast of South America, have also disbanded.

²⁶ Klein and Kyle (1997).

²⁷ Not all of TACA's troubles arose from OSRA. This conference was also under a great deal of pressure from aggressive independent operators beginning in 1997. In addition, TACA suffered several defections after 1998 when the European Union ruled against it in an antitrust dispute over price fixing on inland routes.

Perhaps in anticipation of OSRA's effects on conferences, there was little protest from the shipper community, which generally agreed that the legislation would probably do more to increase efficiency and lower transport costs than simply increase the pricing power of suppliers. On the other hand, some controversy has developed since OSRA's passage, primarily over whether the scales have been tipped too far in favor of large, incumbent, global carriers. Because they tend to operate larger vessels on longer routes, and with a more extensive network of partners, large global carriers, particularly those involved in strategic alliances are in a better position to supply the capacity and services demanded by long-term contracts relative to the smaller, regional market carriers. These factors allow them to more readily capture scale economies and meet the price requirements of long-term contracts. Despite the immediate effects of confidential long-term contracts there remain, as of the end of 1999, more than 300 conferences operating worldwide.²⁹

To summarize, the conference system is an imperfect means of managing competition in the liner shipping industry and in fact may be a relic of the past on United States trade lanes. Research like that of Clyde and Reitzes cited above, and a long history of excess capacity and poor profitability, shows that even with antitrust immunity, ocean liner conferences either have never enjoyed market power or, if they have, they are inept at exploiting it. But to dismiss liner conferences and rely upon the free market to deliver a socially desirable outcome may not be a better alternative. The next section describes

²⁸ Discussion agreements are the weaker cousins of conferences - members are free to discuss rates and services but no binding commitments are required.

²⁹ Based on written correspondence with the Federal Maritime Commission

under what conditions a market is likely to produce a stable and competitive outcome, and how liner shipping may not fit those criteria.

III. Market Failure in Liner Shipping

The preceding section provided a general overview of the difficult competitive conditions facing liner shipping operators, and how cooperation in the industry may be a response to those conditions. In this section the conditions under which any market is apt to fail to produce the competitive outcome are listed. Second, we consider how these conditions might apply to liner shipping markets.

Perfect competition, or at least the ideal theoretical notion of perfect competition, requires several strict conditions to be met. The most essential feature is the presence of a large number of buyers and sellers so that neither has the ability to affect prices. Further, buyers and sellers must be prohibited from forming coalitions that would increase their market power. There must also be free and complete information available to all buyers and sellers so that their production and consumption decisions are made with zero risk. There probably does not exist to any great extent a market that completely fits the above basic criterion. Most markets can be characterized by features such as product differentiation, incomplete information, and economies of scale, high concentration or barriers to entry. Because of these influences, most markets will exhibit at least some degree of imperfection.

Market imperfections can be remedied, in theory, through the intervention of some regulatory agent. Rules can be imposed that govern pricing, entry and other

economic behavior within an industry or market. But since nearly every economic relationship exhibits some degree of uncertainty, the problem for authorities becomes first, which markets require intervention, and second, what form regulation should take. The answer to the first question, ignoring any arguments about income distribution, could revolve around a cost-benefit analysis. Regulatory intervention is efficient when the cost of the intervention is less than the gain in total surplus. The second question, regarding the specific form of the regulation, is less clear and must reflect the particular type of market failure.

According to Layard and Walters (1978), there are four conditions that must hold in order for a market to achieve a competitive outcome:

- 1) There must be no increasing returns to scale by any one producer. Increasing returns imply that larger firms will hold a cost advantage over rivals and will ultimately lead to a monopoly. Unqualified monopolies bring deadweight loss and hence market failure.
- 2) There must be no technological externalities unless “costless” negotiation is possible between the parties involved. In other words, the consumption or production decisions of A must not affect the consumption or production decisions of B. Negative externalities impose costs on other agents that are not paid by party A. Since these costs are unpaid, they do not reflect their true economic value and result in distorted prices. A typical example of this is a production process that pollutes the environment. In this case, the regulator’s concern would be to extract the cost of this

pollution via a tax on the polluters. Since external costs can be psychic as well as physical, any tax level is apt to be incorrect.

- 3) For a free market to be efficient, there must be no market failure connected with uncertainty. If there is uncertainty, a free market can still produce a Pareto optimal outcome, but this requires the unrealistic assumption that agents can insure against all risk. An example of how uncertainty can distort economic decisions is in the over-investment in productive capacity based upon incorrect assumptions about demand. Over-investment is resources that the free market has failed to allocate efficiently. Similarly, under-investment in productive capacity can result in excess demand and a decrease in the utility of consumers and the profits of producers.**
- 4) Layard and Walters state that “for free market equilibrium to be socially optimal, the distribution of factor ownership must be such that each consumer can buy the consumption bundle which corresponds to the welfare maximizing configuration of the economy.” This last condition is meant to insure that no economic agent is excluded from participating in the system.**

Each of the above conditions must hold to achieve a socially optimal or Pareto efficient outcome. Not all and probably few industries fit these criteria strictly, not the least of which is the ocean liner shipping industry, which violates at least two and perhaps all of the above conditions. Moreover, the global nature of its operations requires a trans-

national regulatory regime that involves participants with interests that may be more often in conflict with each other than they are in synch.

On the first point, increasing returns to scale do exist at the plant or vessel level. Although at capacity, the voyage cost function of a vessel takes a discreet jump, over its relevant range of output, the more filled to capacity a vessel is on a particular route the lower its unit cost of making that voyage. The interdependence between ship size and port facilities does present some diseconomies at ports, but studies show that unit cost saving achieved by employing larger vessels outweigh the higher costs to load and unload them at the port³⁰. On the second point, externalities play no small role in the provision of liner services. The value of liner services goes beyond purely economic objectives. Shipping has always been a key feature of geopolitical and defense aims of national governments, offering quick and reliable sea transport during wartime, the ability to extract more completely the surplus generated by world trade, or enhanced national prestige. The external social benefits are considered sufficient to justify the widespread use of state subsidy either in ship building or liner operations. Providing a low-cost means of international transport may, in all practicality, act as a subsidy to a country's industries engaged in trade. Indeed, part of the persistent problem of excess capacity in liner trades may be attributed to market distorting government intervention such as the wide use of state subsidy, cargo reservation policies, differential treatment of port access and other forms of protectionism.³¹

³⁰ See Cullinane, Khanna & Song, (1999), Gilman (1983) and Jansson and Shneerson (1987).

³¹ See Heaver (1991).

On the third point, there is a large element of uncertainty in liner markets.

Uncertainty of future trade flows can cause liner operators to over-invest in capacity, much the same as an electrical utility must keep excess capacity on hand to cover periods of peak demand.

On the fourth and last condition, ocean liner shipping markets have probably not failed historically. Small manufacturers have not been excluded from liner services based on their volume. The large number of liner operators, the advent of containerization and the evolution of the freight consolidation and logistics industries have insured that any agent who can afford liner services have access to them. However, in the new environment of long-term, confidential and volume-based contracts, shippers who are unable to provide enough volume to make a contract attractive to a liner carrier may be forced to contract the services of non-liner or tramp carriers. Non-liner and tramp carriers tend to be less reliable and perhaps more costly than traditional liner carriers. Another alternative is to join shipper associations that use their monopsony power to try and reduce freight rates and improve service for their members. This action, however, may be very costly for a small or infrequent international shipper to undertake.

Liner markets fail to meet at least the first three of the above conditions in United States trade lanes, and since the passage of OSRA, are tending to lean away from meeting the fourth. Consequently, freight rates remain unstable and returns on investment have generally failed to meet global standards. In Heaver (1993) market failure in liner shipping implies "a potential level of price and service instability that is detrimental to trade." He outlines six characteristics of ocean liner shipping that are likely to intensify price competition during period of excess capacity. First is the wide gap between average

costs and marginal costs, which presents carriers faced with unused space with a temptation to slash prices. Second is the non-storable nature of liner shipping output, so that unused space on a voyage is always a wasted revenue opportunity. Third, the importance of service frequency implies that to take vessels out of service during periods of low demand risks losing reputation. In this case it is better to sail with unused space than take a vessel out of rotation. Fourth, aggregate demand (at least for higher value commodities) is inelastic to freight rates so that in order to achieve full capacity, freight rate reductions have to be steep. Fifth, the practice of differential pricing "...encourages focused competitive pressure." That is, the wide range of commodities and prices gives rival carriers increased opportunity to capture market share by selective price cutting. Finally, ships are long-lived assets, often in service for 25 years or more, so that once excess capacity is created, it will persist.

The fear among shippers and smaller carriers is that, absent appropriate regulation, the ocean liner shipping industry is likely to become increasingly concentrated with a few global carriers dominating major liner markets. This fear is not without precedent. In the Addyston Pipe Case during the late 1800s, the United States government, under the Sherman Act, was successful in breaking up a cooperative agreement consisting of six producers of cast iron pipe. This cartel cooperated in submitting bids for government contracts by holding private bidding sessions where only the cartel member with the lowest bid would be permitted to submit an official bid for the contract. If successful, the bidder would then contribute the difference between his bid and that of the highest bidder to a common fund. The proceeds of the fund would subsequently be divided according to each member's share of productive capacity to

defray overhead costs. Telser (1987) explains that even though on the surface, the cartel appears to have raised the price of cast iron pipe, in reality, given the cost conditions of the industry at the time, it was a more efficient process than if each firm acted individually. By breaking up the arrangement, the United States government created conditions that led to a wave of mergers in the cast iron pipe industry, with the largest firm eventually holding 68% of the cast iron pipe manufacturing capacity. Other collusive industries with high fixed costs such as railroading, iron and steel, meat packing and sugar, were also affected by the 1895 Sherman Act, and according to Bittlemeyer (1985) were driven towards higher concentration during the first two decades of the 20th century. Moreover, the merger wave was less likely the result of monopoly rent-seeking, but more likely a means to avoid ruinous competition.

The results from other industries have resonance for deep-sea liner shipping. Antitrust immunity for liner conferences has never been completely secure and is often subject to intense scrutiny by regulatory authorities in the United States, Europe and elsewhere.³² The question is whether the removal of antitrust immunity would necessarily bring about a more heavily concentrated ocean liner shipping industry such as happened in other fields in the early 20th century in the United States. The answer to this question requires a deeper understanding of liner industry structure, conduct and performance including a thorough examination of its cost conditions.

³² A recent example was a multimillion dollar judgement against the Trans-Atlantic Conference Agreement (TACA) in 1998. The European Union determined that the conference illegally fixed prices for inland transport.

IV. Market Structure, Conduct and Performance

The way in which firms behave in a given industry can often be inferred by the Structure-Conduct-Performance (SCP) paradigm. SCP was developed by Joe Bain in the late 1960s, as a standardized method for assessing how industrial concentration affects the social welfare function, and whether regulatory intervention is required to correct inequities. The industrial organization paradigm says that market structure determines performance, usually measured in terms of profitability. Conduct is defined as the way in which firms interact with each other, buyers and potential entrants. Structure is most often inferred by measures of concentration such as the Herfindahl Index (HHI), calculated as the sum of the squares of market shares for all firms in an industry or by a four-firm or an eight-firm concentration ratio calculated as the sum of market shares for the four or eight largest firms. Concentration implies market power in terms of pricing and the functional relationship with profitability is positive. Conduct refers to how firms within a given market structure determine their pricing and output decisions. Concentrated markets are assumed to foster conduct that is collusive in nature, either tacitly or explicitly through cartel-like arrangements to coordinate action.

Performance speaks to the welfare aspects of the interaction. Markets that are highly concentrated can be expected to produce a socially undesirable outcome, since prices are likely to lie above the marginal cost of production.

Structure

Researchers have uncovered several potential sources of concentration.³³ Entry barriers such as product differentiation, including reputation and goodwill, the cost advantages of incumbent firms and economies of scale each contribute to concentration. Other determinants include high sunk costs, rapid technical change and high fixed costs relative to variable costs.

The application of the above factors to liner shipping markets suggests that these markets should be highly concentrated. Indeed, when considering the structure of liner shipping markets on United States trade lanes, the market shares of conference members and now global alliances are usually grouped together. This makes liner shipping markets appear heavily concentrated with upwards of 80% of the major markets controlled by conferences. The statistics, however, are very misleading. In United States trades, the conferences are required to follow an open membership policy, that is, any carrier in the trade that wishes to join the conference must be permitted to do so. At the same time, any carrier that wishes to leave the conference must also be free to do so without reprisal. This policy, made law through the 1984 Shipping Act, was designed to reduce entry and exit barriers and maintain competitive pricing. The 1984 Act also limited the conference's ability to discipline members who pursued "independent action." Carriers within conferences were thus free to undercut fellow members without fear of economic reprisal. The above two reforms were particularly effective in reducing the conference's ability to behave as a price fixing cartel. Hence, in assessing concentration in ocean liner

³³ See Waterson (1984).

shipping markets, there is debate about whether the conference should be considered as a single firm. If the market shares of conference members are disaggregated so that each member appears as an individual firm, the industry looks to be only moderately concentrated according to the FTC merger guidelines. The table below compares the HHI for various trade lanes in 1992 and 1999. According to United States Department of Justice merger guidelines, an industry with an HHI of 1800 or above is considered highly concentrated and likely to pose a threat of anticompetitive behavior.

Table I. Liner shipping concentration statistics, various U.S. trade lanes.

<u>Trade Lane</u>	<u>Conference Aggregate HHI</u>		<u>Dissaggregated HHI</u>	
	<u>1992</u>	<u>1999</u>	<u>1992</u>	<u>1999</u>
Westbound TransPac	6489	6457	725	692
Eastbound TransPac	7502	7314	720	644
Westbound North Atlantic	4192	3601	623	535
Eastbound North Atlantic	3754	3470	581	521
Westbound The Mediterranean	4714	1163	770	730
Eastbound The Mediterranean	5768	1413	881	749
Northbound W.C. South America	2328	3779	1447	1017
Southbound W. C. South America	2098	4832	903	1080
Northbound Oceania	7990	6973	2673	2494
Southbound Oceania	5508	4579	1782	1691

Highly concentrated industries raise concerns among antitrust authorities that, all else equal, of a heightened risk of anticompetitive behavior. The more concentrated a particular product or geographic market, the higher is the potential for collusion to earn monopoly rents among incumbent firms. Under that logic, if conferences or other collusive agreements are truly binding, then the above Herfindahl indices suggest that liner shipping has a potential for highly anti-competitive behavior in each market. But that implies that profits should be supra-normal and dynamically stable, that is, returns on investment should hover within a well-defined range over time. Prices would be stable because in truly binding arrangements, there is little incentive for members to cheat (offer their services at a price lower than the conference rate). The fact that profitability in liner shipping has historically failed to achieve global standards implies a highly competitive market and an unstable non-binding cartel arrangement. The argument also ignores the effects of other factors such as core emptiness and contestable markets that may supercede the ability of collusive agreements to maintain supra-normal profits. Finally, the Shipping Act of 1984 allowance for independent action may render the market share statistics misleading. Even though the conference is a legally sanctioned collusive agreement, its member's ability to initiate rate actions independently of the conference suggests that the market is far less concentrated than what is indicated by the HHI.

Conduct

Under the assumption that the conference is a truly binding collusive agreement, the number of players in the liner shipping market can be distilled down to two broad

groups: incumbents (the conference) and independents (non-conference carriers).

Conduct refers to the competitive interaction between these two groups of players, or the classification of the equilibrium that develops as a result of that interaction. There are three fundamental models that industrial organization theorists use to explain conduct in imperfectly competitive markets: Bertrand, Cournot or Stackelberg, and the cartel model.³⁴ In the Bertrand equilibrium, there is no cooperation among the oligopolists and price is driven to marginal cost. In the Cournot or Stackelberg equilibrium, firms choose quantities taking their rival's decision as given.³⁵ In the resulting equilibrium, quantity falls below the competitive output but above the monopoly output. Collusion is tacit rather than explicit. In the cartel model, firms collude to raise and maintain price to the monopoly level.

The Cournot model is the "workhorse" of industrial economics. Central to its implementation is the assumption that the quantity setting behavior of rival firms is fixed. That is, the quantity setting behavior of one firm does not affect the behavior of others in the same market. And it is this particular aspect of the Cournot model that comes under the heaviest criticism. In real world applications, it may be unreasonable to expect that

³⁴ These three models encompass the most basic strategic interactions among oligopolists. Using these basic foundations, game theorists have built increasingly complex models of strategic behavior such as decisions regarding investment, output, research and development, mergers and acquisitions.

³⁵ In the Cournot model, the choice variable is output and the outcome is a Nash equilibrium where no one player can be made better off without making the other player worse off. In Cournot, players choose outputs simultaneously. In Stackelberg's model, the choice variable is capacity, although it can easily be extended to choosing output. This model differs from Cournot in that the players choose their capacities (or outputs) sequentially. From Stackelberg's model arose the notion of "first mover advantage" where the oligopolist that invests in capacity first can govern the capacity choice of its rival. There is an inverse relationship between the first mover's output and the second mover's output; however, it is not one-to-one. The rival's best response function is to decrease output when the first mover increases output, but less than proportionately. Because the first mover knows this, it can compel its rival to reduce output by increasing its own. Hence, the first mover will produce more in the sequential game than in the simultaneous or Cournot game. Since the second mover reacts less than proportionally to the first mover, aggregate output is also higher and prices lower than in the Cournot game. In terms of entry deterrence, Stackelberg's formulation is more apt to describe an oligopolist's behavior in the liner shipping industry since the industry can be described as consisting of incumbent firms (leaders) and fringe firms (followers).

the actions of one firm in a duopolistic or oligopolistic industry do not affect actions of other firms. An alternative model to describe the dynamic interaction of firms in imperfectly competitive markets is known as conjectural variations. Economists use conjectural variations to draw conclusions about the type of equilibrium in a dynamic setting. That is, the Cournot and Bertrand models can be nested with the conjectural variations approach in order to quantify firm behavior. Conjectural variations assumes that each firm believes that its choice of price or quantity can affect its rival's choice of price and quantity and that the particular way in which rivals react can characterize the conduct as either Cournot or Bertrand. The approach is empirical and in econometric studies, conjectural variations are measured as "conduct parameters" or parameters derived as the response of firm i to decisions of firm j . For example, in Brander and Zhang (1990), price and cost data were used to test the conjectural variations model in duopoly airline markets. Even though they did not include all variables that may influence pricing, there were able to conclude, based on their regressions, that the conduct of firms in their dataset more closely followed Cournot rather than Bertrand or the cartel model. Formally, conjectural variations can be represented by $v = \frac{dx_i}{dx_j}$, where v is the conduct parameter. Inferences about competitive behavior can be drawn through this relationship.

The application of conjectural variations to liner shipping markets seems to follow naturally. We have two players, incumbents and independents, producing a product that is approximately homogeneous. Price and cost data are not readily available; however, inferences regarding firm conduct can be made using capacity choice. Liner shipping

capacity is variable, mobile (at least imperfectly) and closely associated with price. For these reasons it is reasonable to state that firms compete, at least indirectly, on the basis of capacity, and that the response of rival players to introductions or reductions in capacity in a particular market can characterize the equilibrium. For example, it may be reasonable to state that at least on the surface, the existence of excess capacity, *all else equal*, can be taken as a sign that conferences and independents likely behave in a Bertrand-like manner. Otherwise, excess capacity would be reduced by agreement to maintain higher freight rates through collusive arrangements that are either explicit as in the cartel model, or implicit as in the Cournot model. We can also eliminate the cartel model as a consideration. A cartel implies a consortium of firms that agree to behave as a monopoly. This would suggest that firms in liner shipping earn supra-normal or monopoly profits. The reality of financial performance in liner shipping is very different. Moreover, while conferences do set joint prices, they are prohibited from setting joint service levels. In other words, conferences do not have legal authority to allocate market shares among members. Rather, conferences set prices, then compete on service. A true cartel controls both price and output decisions of their members. This is one reason why there are frequent defections from liner conferences by individual firms. By U.S. law, the conference is prohibited from taking punitive action against defectors and must also agree to permit individual lines to become members at will.

The conduct parameter $\nu = \frac{dx_i}{dx_j}$ ranges in value from -1 to +1. When the choice

variable is output, a value of -1 implies Bertrand competition, a value of 0 implies Cournot and +1 implies a cartel. The reasoning follows directly from the associated

reaction functions.³⁶ In a pure Bertrand equilibrium, the reaction functions lay on top of one another with a slope of -1. In a duopoly, if firm 1 decreases output to raise prices, it is met with a one-for-one increase in the output of firm 2. Firm 1 is aware of this and as a result does not restrict its output. The cartel model falls at the other extreme. When firm 1 decreases output, it knows through the cartel arrangement that firm 2 will follow suit one-for-one. Hence output is restricted and prices rise to the monopoly level. In the equilibrium of Cournot, each firm takes its rival's output decision as given. That is, firm 1 chooses its own profit-maximizing output, taking firm 2's output as given. This implies that the conduct parameter is 0. The analysis can be extended to incorporate other strategic variables, including the choice of capacity.

Performance

Performance is usually measured by profitability (Shy, 1995). It is not the primary focus of this dissertation to determine performance. There is already sufficient evidence to suggest that profitability in liner shipping historically fails to meet generally accepted global standards. The hypothesis is that it is at least partially a result of excess capacity caused by the behavioral interaction between conferences and independents, as well as the particular characteristics of liner shipping markets, that may create excess capacity and help to preclude firms from earning normal profits. What follows is a discussion of the various market conditions that may offer alternative explanations for persistent excess capacity. Natural monopoly, contestable markets, the theory of the core and

³⁶ See Martin (1993) pp 26.

technological change are each discussed as they may relate to excess capacity in ocean liner shipping

V. Natural Monopoly and Liner Shipping Costs

Competition in natural monopoly markets is unworkable, meaning that with two or more non-cooperative firms, competition will inevitably produce an unstable and socially inefficient outcome characterized by high rates of entry, exit and prolonged periods of excess capacity. This section begins by providing an overview of natural monopoly - its formal definition and conditions under which it might occur. It owes a great deal to William Sharkey's 1982 book, *The Theory of Natural Monopoly*. The section ends by describing how ocean liner shipping may fit the generally accepted criterion for natural monopoly described in Sharkey's work.

Farrar (cited in Sharkey, 1982) enumerated five conditions that must be met in order for a natural monopoly to exist:

- 1) The industry must supply an essential product or service
- 2) The industry must occupy a favorable location for production
- 3) The outputs of the industry must be non-storable
- 4) Production must be characterized by economies of scale
- 5) The customers of the industry must require a "certain and a well-defined harmonious arrangement which can only be attained by a single supplier."

Of these five conditions, two through five may be considered necessary but not sufficient, while condition one is necessary and sufficient. For example, by conditions two through five, most cities in the United States can realistically support just one professional baseball team. This suggests that baseball is a natural monopoly. However, most would probably agree that baseball is not an essential service, a violation of the first condition.³⁷

Henry Carter Adams (cited in Sharkey, 1982) relied almost exclusively on the cost function to classify an industry as a natural monopoly and was one of the first economists to advocate regulatory intervention in these markets. He wrote, "Where the law of increasing returns works with any degree of intensity, the principle of free competition is powerless to exercise a healthy regulating influence."

Richard Ely (cited in Sharkey, 1982) relied much less on the technical aspects of the cost function and more on industry peculiarities that render competition "unsuitable." He identified three classes of natural monopoly that are listed in Sharkey:

- (1) those dependent on unique sources of supply,
- (2) those based on secrecy or patents and
- (3) those arising from "peculiar properties of the industry."

Ely's first and second class natural monopolies are self-explanatory. The peculiar properties described in the third class need further qualification. They refer to any

³⁷ This analogy was brought to my attention by Prof. David Gabel.

condition that “makes competition self-destructive.” Ely listed three such conditions. First, where there is limited potential for product differentiation such that small changes in price produce large changes in demand. Second, where it is impossible to support a large number of plants, either because of the advantages of large-scale production (Sharkey’s cost-sub-additivity at the plant level) in a single plant or because it is physically impossible to accommodate more than a few plants in a single market. The latter may be due to special geographical requirements and is closely related to Farrar’s second condition that states the industry must occupy a favorable location for production. Third, where high fixed cost to variable cost ratios prevail. This implies that natural monopolies tend to occur in industries that require the commitment of large and perhaps unrecoverable capital investment.

Whatever the analytical approach, Farrar, Adams, Sharkey and Ely by implication distinguish natural monopolies from competitive markets by the presence of economies of scale. These economies have to be found in both production (the necessary condition) and distribution (the sufficient condition). Formally, economies of scale exist if the total industry cost function is sub-additive; that is, if the cost of producing output is lower for one firm than the sum of costs for two or more firms producing the same output. A sub-additive cost function is characterized by declining average cost over the possible range of output. It can be formally represented by the expression $C(y) < \sum_{i=1}^n C(y^i)$. This equation states simply that the total cost, C of producing output y incurred by one firm, is less than the sum of the costs over firms $i=1$ to n producing the same output. Economies of scale in production require plant-level cost sub-additivities while economies of scale in distribution depend on how the geographic market is defined. A firm enjoying economies

of scale when serving a particular market may find those economies lessened if the market is broadened, either geographically, or in the case of a multi-product firm, in the variety of output. The nature of demand also has implications for market definition. Highly variable demand requires investment in capacity that will be idle for significant periods of time. To minimize the time plants are idle, the firm is required to supply as many customers as is possible. This in and of itself can potentially create economies of scale in distribution that are sufficient to overwhelm diseconomies in production.

At the firm level, cost sub-additivity exists if, and only if, there is market failure, defined as a condition that prevents the establishment of a competitive equilibrium with more than one firm. The argument follows directly from the properties of cost sub-additivity. Cost sub-additivity requires that to minimize costs, there must be no more than one firm operating in the market.

Sharkey (1982) identified two sufficient but not necessary properties of strict cost sub-additivity in a single output firm that could qualify it as a natural monopoly. First, the cost function must exhibit concavity, that is, average costs must be falling over a certain range of output. If average costs decline for all levels of output then the cost function is said to be globally concave. Second, the cost function must be strictly concave so that marginal costs are decreasing in output. The necessary condition is simply that the unit cost of a single firm producing output must be less than the unit cost of two firms producing the same output. For a multi-product firm, the above properties must be supplemented by cost complementarity, that is, the production of one good must exert a negative influence on the cost to produce a second good. If cost complementarities exist, then the firm can be said to exhibit economies of scope.

Economies of scope exist if the total cost of one firm producing more than one output is less than if one firm produces each output.

Sharkey also identified three sources of cost sub-additivity or economies of scale at the plant level. First, the condition is likely to be found in industries where capital is of a highly specific nature. The economics of specialization allow a certain task to be completed in the most efficient manner, giving way to economies of scale. Second is the “existence of unavoidable indivisibilities in the production process.” This refers to plants in industries with high fixed costs relative to variable costs or costs that are relatively insensitive to the volume of production. Third, economies of scale are more likely to be found at the plant level in industries with uncertain or highly variable demand. The more that demand fluctuates, the higher must inventory be in order to satisfy that demand at all points in time. The larger the inventory or productive capacity, the lower will be average costs for any given level of output. The argument does not imply that larger capacity automatically produces economies of scale, just that it increases the likelihood of economies of scale.

Evidence of Natural Monopoly in Liner Shipping

If liner shipping can indeed be classified as a natural monopoly then that classification may partly or fully explain the industry’s chronic excess capacity. The remainder of this section attempts to apply the definitions of natural monopoly listed above to liner shipping. Although there is no attempt to prove quantitatively that the liner

shipping industry is, or is not a natural monopoly, the definitions outlined above may provide some insight into one potential cause of excess capacity in liner shipping.

With respect to Farrar's five conditions, that the industry must supply an essential product or service, occupy a favorable location for production, produce output that is non-storable, be characterized by economies of scale and whose customers must require a "certain and a well-defined harmonious arrangement which can only be attained by a single supplier," the liner shipping industry roughly fits each. First, international trade is an essential component of GNP, and the liner shipping industry provides a steady, reliable and cost-effective means of transport across oceans. Were it not for adequate liner services, world trade, especially for manufactured goods, would never have achieved high levels of growth that prevails today. Liner services are especially beneficial to small manufacturers engaged in international trade that could not entirely fill a vessel with their own output.

Second, liner shipping is restricted geographically to countries with adequate port facilities. Containerization of liner cargoes requires a network of specialized handling facilities at ports and an extensive inter-modal infrastructure that includes adequate rail, truck and barge equipment to fully exploit the economies gained by containerization.

Third, the output of liner shipping is by nature non-storable. Carriers cannot wait until their vessels are full before making a voyage but instead must adhere to a rigid sailing schedule. Therefore, any unfilled space on the vessel is revenue is lost forever.

The fourth point is less clear. Production, once ocean borne, does exhibit economies of scale. As vessels have gotten larger and more technically advanced over time, unit costs have fallen. However, as vessels get larger, they require more certain and

higher levels of demand in order to capture those economies. Furthermore, economies of scale gained through the use of larger vessels can potentially be erased in part by diseconomies at port facilities and at harbors that lack the sufficient depth to accommodate them. Economies of scale and more specifically, cost sub-additivity in container shipping are discussed in more detail under Sharkey's conditions below.

The fifth and final point is also somewhat controversial. Shippers do require a stable and certain means by which they can transport their goods. The reliance on trade, however, differs by country so that this conclusion cannot be considered to apply universally.

Liner shipping is also roughly in line with Ely's conditions to describe what he termed as the third class of natural monopoly, that is, those rising from "peculiarities of the industry". Aside from marginal differences in the speed and reliability of transport, the product is by and large undifferentiated, requires large plants (vessels) to capture economies of scale and requires a high fixed to variable cost ratio.

Sharkey's conditions are technical parameters that require a more in-depth analysis. The intent here is not to prove them by an econometric analysis of liner shipping costs but to assess whether or not a reasonable case can be made that liner shipping costs could potentially fall under Sharkey's conditions for natural monopoly cost functions. First, liner shipping at least appears to fit Sharkey's criteria for cost sub-additivity at both the plant and firm level. At the firm level, to apply Sharkey's conditions (economies of scale and strict cost function concavity) to liner shipping, it must be made clear exactly what the output of a single liner firm is. Either it is a single movement of a commodity for a particular commodity-route pair, in which case liner

shipping firms are single-product firms, or multiple commodities moving between multiple routes, in which case liner shipping is a multi-product firm. If the latter definition applies, then in addition to the other requirements stated above, Sharkey's added condition of cost complementarity or economies of scope must be satisfied. With respect to the geographic market, ocean liner shipping firms can be divided into two classes: regional or niche carriers and global carriers. Regional or niche carriers generally serve one trade route, for example, the East Coast of South America to the East Coast of the United States. However, they generally call at more than one port within that trade route. They may also specialize in a certain type of cargo such as forest products or heavy lift cargo that may travel aboard multi-purpose vessels.³⁸ On the other hand, global carriers serve several trade routes, and several port pairs within those trade routes. One voyage between two trading partners may include multiple port calls and more than one region. Hence, the question of whether liner shipping is a multi-product or a single-product enterprise depends upon how the geographic and product markets are defined. If the definition is narrowed down to particular port pairs with the container itself defined as output, then it can be classified as a single-product enterprise. If the definitions include more than one port pair on a single voyage or considers each product a separate output, then liner shipping more closely resembles a multi-product enterprise. The distinction is

³⁸ Multi-purpose vessels are designed to carry bulk, heavy lift or roll-on/roll-off cargoes in addition to providing slots for containerized cargoes. They are more likely to be found in the short sea trades where economies of scale are less important than long-haul trades.

not outwardly clear. Previous studies of liner shipping costs have not directly addressed the issue, although they appear to treat liner shipping output as a single product.³⁹

Studies of a similar industry, such as rail transport, suggest that liner shipping is a multi-product enterprise. In terms of the geographic market, the liner carrier that serves more than one port pair on a single voyage is serving two separate markets. In that sense, liner carriers are multi-product enterprises. In terms of the product market, the containerization of liner cargoes has created what is essentially a single, standardized product. That is, regardless of the particular commodity inside the container, the output of the carrier is measured as the movement of that container to and from specific locations. Yet the ability to price discriminate by commodity, each with its own demand elasticity, appears to make liner shipping a multi-product firm. This is especially true when we consider that refrigerated cargo can be carried alongside non-refrigerated cargoes. On the same vessel, and the same voyage, the carrier can provide transport from point *A* to point *B* of commodity *X* and from point *A* to point *C* of commodity *Y*. In this sense, the liner carrier is a multi-product firm even though output is measured in terms of the movement of the containers themselves. For this reason, Sharkey's condition that the multi-product firm exhibit economies of scope must be satisfied in order to classify ocean liner shipping as a natural monopoly.

At the plant level, Sharkey's conditions hold, at least qualitatively. First, it is clear that capital is of a very specific nature. Fully cellular container ships, on which the great majority of containerized liner trade is transported, are designed for no other purpose. A

³⁹ See Klein and Kyle (1997), Cullinane, Khanna and Song (1999), Veldman (1991) and Davies (1983). Although there is no mention in these studies of the distinction between single versus multiproduct firms, Davies (1986), in a subsequent paper on liner market contestability, asserts that the industry is a multi-product firm.

fully cellular vessel is constructed around slots, in which some standard-size container (usually forty feet in length) fits and is secured. There may also be lifting gear on the vessels designed to meet globally standardized specifications that can be used only for the loading and unloading of containers. There are no holds for bulk cargoes, vehicles, or any other miscellaneous cargo. There exist general cargo, roll-on roll-off vessels, and some combination bulk/container ships in the liner trades, but the volume of containers they typically carry is of little significance relative to the volume carried by fully cellular vessels. Other capital equipment such as land-side lifting gear or shipboard lashing equipment are of globally standardized dimensions to facilitate the flow of inter-modal volumes, and, as such, are highly specific in nature. Second, it is evident that there are indivisibilities in the production process. Although the speed of the vessel can be altered slightly to reduce fuel costs on voyages with low load factors (capacity utilization), the liner carrier must still keep a schedule of pick-up and delivery. That is, it must make the voyage whether its load factor guarantees a break-even point or not, and once underway, must deliver the cargo at the originally agreed upon time and place. Third, the condition that demand must be highly variable is roughly applicable to liner shipping.

Containerized trade is seasonal and is subject to periodic demand shocks. For example, the trans-Pacific trade, which includes the United States to and from Northeast and Southeast Asia, underwent a severe and unanticipated shock in 1997 when several countries in Asia were forced to devalue their currencies. After years of building capacity to satisfy the anticipated increases in demand on this route, the demand shock in Asia left them with severe excess capacity on their export voyages from the United States and

Europe. The severe imbalances left carriers with huge container repositioning costs that had to eventually be passed along to shippers in the form of surcharges.

With respect to Sharkey's cost conditions, various authors have investigated liner shipping costs.⁴⁰ At the plant (vessel) level, most find that average shipping costs, i.e. direct costs of operating the vessel, decline as ship size increases. However, at the high end of the range, network effects begin to dominate, and bottlenecks are likely to occur. The diseconomies in the loading and unloading of the vessel cause the average total cost curve to exhibit the classic U-shape. In Veldman (1991) the optimum ship size (minimum average total cost) was at 3,200 TEUs⁴¹. Increasing average costs, however, do not automatically disqualify liner shipping as a natural monopoly industry. There is nothing that says that a more intense level of vertical integration would not solve this bottleneck problem. Indeed, part of the reason for the global alliances is to rationalize capacity and schedules at congested ports and unloading facilities.

At least part of the higher costs of unloading large vessels is simply that sea port capacity has for the most part failed to keep pace with the rapid pace of technical change in vessel design. Most ports in the world, including in the United States, are quasi-public corporations, although the concept of full privatization has engendered some interest in less-developed countries. In the developed countries of Europe and the United States, regulatory authorities are wary of permitting too much vertical integration, fearing that a fully integrated liner service would be in a position to easily foreclose on rival operators. This would adversely affect inland transport providers, extract economic rents from labor

⁴⁰ Ibid.

⁴¹ TEU (Twenty-foot Equivalent Unit) is the standard unit of measure in the container shipping business. It denotes the length of the container used to ship goods.

unions and ultimately be anti-competitive. Although ports compete with each other, the public nature of ownership may restrict capital investment to levels that are inadequate to keep pace with the level of technical change in vessel size. This is evident in east coast United States ports which require significant investment in harbor dredging before they can accommodate the new generation of mega-container ships. In addition, labor costs at ports are often extremely high, in part because of the monopsony power of longshoremen unions. Within the port there may exist private marine terminal operators or stevedoring firms whose sole purpose is to provide lifting services to carriers on a contractual basis. Carriers may also own and operate this equipment themselves as part of a strategy of vertical integration. Typically, the land on which they operate is leased from the port authority, and as such, state rules governing the employment of labor (longshoremen) remain in effect. In fact, vessels themselves may carry lifting equipment on board as part of their physical structure. A proper analysis would consider the effect of carrier-owned terminal operations on average total costs. Under the assumption that a vertically integrated liner carrier will minimize costs, investment in port capacity would, under private ownership, be more likely. Potentially, at least, there are economies of scale at the plant level for the entire range of output.

Economies of scale are also found at the firm or fleet level. Klein and Kyle (1997) estimated a trans-log variable profit function for 15 subsidized United States liner carriers for the period 1973-82. Technical change during this period was rapid and the data reflect this clearly. The economy of scale parameter was highest at the end of the period. Returns to scale at the firm level are especially prevalent with respect to cargo handling. The elasticity of variable profit with respect to cargo handling costs was

significantly higher than one. Again, were carriers more vertically integrated, those economies would more likely be captured and the U-shape average total cost curve that now prevails may very well flatten out. To test this would require a comparison of cost data between carriers that own and operate their own terminal networks and those that rely exclusively on state-run port facilities.

Davies (1983) provides a highly detailed examination of liner shipping costs. He finds that the most conspicuous feature of liner shipping costs in the short-run are the high ratio of fixed to variable costs. To begin with, the initial capital commitment is high relative to other shipping markets. To operate a liner service at minimum efficient scale requires not just one vessel, but a fleet of vessels, the number of which depends on the length of the trade route and on the demanded level of service frequency. Container ships are expensive relative to dry bulk and break-bulk ships. The need for speed requires a relatively sophisticated hull and engine design while the vessel's structure is made more complicated by the need to build the ship around the cells that hold the containers. In addition, container ships require a host of complementary assets such as a fleet of containers and container chassis. In some trades, particularly those in developing countries with inadequate port facilities, operators may require on-board lifting gear. Because liner shipping serves so many product and geographic markets, it requires an extensive sales and administrative infrastructure. Capital commitment is just one element of liner fixed costs. The remainder is an artifact of its committed nature. Providing a regularly-scheduled service at the demanded level of frequency transforms cost that in most other industries would be considered variable, into fixed costs. These include such voyage expenses as labor, fuel, port charges and tug boat fees, crew provisions, insurance,

and so on. Cargo handling charges may be variable in some instances but in others, particularly in trades that are imbalanced, they will be fixed. This is because in an imbalanced trade, carriers will have to transport and position empty containers on a regular basis. Davies estimated that fixed costs are between 80-90% of liner service total costs. Franck and Bunel (1991), citing a 1979 paper by R. A. Ellsworth, confirms this. In the short-run, these costs are unavoidable. Carriers that deviate from their regular schedule in periods of low demand risk losing goodwill and market share to competing firms when positive demand growth returns. In addition, if during downturns, the carrier reduces output and sells off some capacity, it will be less prepared than its rivals for times when demand turns up again. This argument relates to the peak load problem discussed above. Carriers must keep a certain level of reserve capacity on hand to meet spikes in demand or else risk losing market share.

Since fixed costs dominate, the average total cost curve for an individual ship falls steeply until full capacity is reached. This is because fixed costs per unit of cargo fall rapidly while variable costs remain relatively constant. At the high end of the output range, variable costs will rise relative to fixed costs because stevedoring efforts become more difficult. However, Davies found that the rise in variable costs at the high end of the output range is insufficient to cause the average total cost curve to turn up significantly before maximum capacity of the vessel is reached. Davies' results are close to Veldman above except that when Davies wrote his paper, container ships were significantly smaller on average than at the time of Veldman's work. A smaller vessel requires less stevedoring services and hence variable costs are lower than they are for a larger vessel.

Davies work implies a constant marginal cost curve for an individual plant (vessel). Thus, in order to maximize profits or minimize costs, ocean liner carriers choose to maximize capacity utilization. This is because if marginal costs are constant with respect to output, while fixed costs per unit of output are falling steeply, average cost is minimized only when full capacity is reached. Cost conditions such as these set the stage for the types of destructive competition described earlier. To fill their vessels to full capacity might entail slashing freight rates when demand turns down, sacrificing short-run profitability for long-term profitability and giving rise to protracted and ferocious rate wars.

The question now is whether it is reasonable to conclude, given the work of Davies, and Veldman and Klein and Kyles, that Sharkey's cost conditions for natural monopoly at the plant level are consistent with liner shipping. No attempt is made in this dissertation to gather empirical evidence regarding the cost function of liner shipping, however, in each of the studies above, the average total cost function does exhibit concavity for most of its range, and marginal costs are constant. These characteristics do fit Sharkey's criteria for natural monopoly. For a multi-product monopoly, Sharkey adds the condition of cost complementarity. Ignoring diseconomies that may raise costs at seaports, it is reasonable to state that the larger the size of the load, the smaller the unit cost of transporting that load. A hypothetical example will illustrate. Suppose a shipper has two cargoes, one that requires refrigeration while the other does not. These are two separate products. Suppose further that one product needs to go to Port A, and the other to Port B each from the same origin. It is not difficult to see that it would probably be more cost efficient for one vessel that can accommodate both types of cargo deployed to ship both

products on the same voyage, as opposed to two vessels, one with refrigeration technology aboard and one without. Indeed, this is the case in modern liner shipping markets. Modern vessels are designed with a certain number of refrigeration “plugs” or container slots that are wired to a central power unit on the ship and that can power the refrigeration equipment inside specially designed containers. Hence, the cost function can be aptly described to exhibit complementarity properties as well.

It remains to investigate how the industry’s tendency towards natural monopoly may contribute to its chronic excess capacity and its failure to achieve a competitive equilibrium. If one firm operating in a single market faces a downward sloping average cost curve for the entire range of output, the question is whether the addition of a second firm prevents the other from reaching minimum cost. In other words, given that costs are minimized when a ship reaches full capacity, is the market large enough to ensure that both firms have sufficient cargo to operate at that level? Shippers want large, efficient vessels that minimize transportation costs and make their goods more competitive in overseas markets. To engage in those types of investments requires sufficient demand to keep the vessel operating at full capacity. If one ship is sufficient, then two ships are socially wasteful. This is the essence of a natural monopoly, that when two or more firms operate (assuming like Sharkey that they possess identical cost functions), total industry costs rise and social welfare is reduced.

The particular type of failure is a fundamental element in determining an appropriate remedial strategy. Sharkey states that “... sub-additivity may be said to exist if and only if there is market failure.” He listed three sources of cost sub-additivity at the firm level falling under a broader category of sub-optimal competition as opposed to a condition

where no equilibrium exists at all. These include Hotelling's 1929 example of two stores competing for the optimal location along a length of road, the prisoner's dilemma and the problem of dynamic capacity expansion. It is the latter condition that is most associated with market failure in the liner shipping industry.

The dynamic capacity expansion problem in liner shipping can be explained as follows. It is generally agreed that capacity costs (stowage factor) are a principal determinant of liner shipping freight rates (Jansson & Shneerson 1986). Excess industry capacity will thus restrict carriers' ability to maintain sufficient revenues to cover fixed costs. When faced with linear demand growth over time, and fixed costs to install new capacity, it is optimal for firms to add capacity in discreet units at equally spaced intervals (Sharkey 1982). This incremental approach permits the supplier to more evenly match capacity with demand growth while economizing on the fixed costs of adding capacity. When there are two or more non-collusive firms, each will choose its own capacity expansion path independently of the other. This is likely to produce prolonged bouts of excess industry capacity. The reason is that capacity can only be added in large (relative to demand increments) and discreet sizes. Each firm adds q units of capacity at specific intervals. However, demand growth may call for just $\frac{q}{n}$ units of capacity, where n is the number of firms in the market. If the unit costs of adding capacity are non-linear, then each firm choosing independently will attempt to economize on those costs by adding more capacity at less frequent intervals, resulting in a worsening of excess capacity (Sharkey 1982). The problem becomes even more severe when demand fluctuates. Fluctuating demand will cause uncertainty in the decision to add capacity. If the cost of

supply shortages is higher than the cost of carrying excess capacity, the carrier is more likely to err on the side of excess capacity rather than be caught short during periods of high demand.

Now suppose that firms in the above industry are permitted to collude. By sharing resources or merging, the problem of dynamic capacity expansion in industries that require lumpy supply side investments eases. Rather than each firm adding q units of capacity when demand for each firm is higher by $\frac{q}{2}$, a collusive agreement may offer each firm's unused excess capacity to meet the growth in demand. In liner shipping, this line of thought gave rise to vessel sharing arrangements and carrier alliances.

The above section suggests that the liner shipping industry tends towards natural monopoly and as a result will exhibit excess capacity when more than one firm operates. This can have social welfare implications since at the minimum, it is better from a social welfare standpoint to permit firms to cooperate to rationalize services than to allow unfettered competition. Yet there are countervailing factors that may preclude governments from regulating the industry as a natural monopoly, at least on a global basis. Not the least of these is significant positive externalities that liner shipping offers to nations engaged in trade. Some of these and their implications for entry and sustainability are discussed below.

In the liner shipping industry, even the prospect of negative profits may not deter a heavily subsidized entrant since losses incurred can be wholly or in part recovered through government payments. The social welfare loss in this case will be even greater, but since it will be shared between the subsidizing government and the incumbent liners

there is a larger probability that the gain to the subsidizing government in the form of positive externalities will outweigh the direct and opportunity cost of subsidies.

Panzar and Willig (1977) discuss sustainability of natural monopoly when free entry exists. Entry in their model occurs as long as the potential profit is non-negative. The implication is that price wars are sufficiently costly to convince a potential entrant that as long as he is small relative to the incumbent monopolist, he is unlikely to elicit an aggressive response. In the Panzar and Willig model, there is a regulator whose problem is to choose a price to maximize social welfare (zero economic profits) without precluding entry by innovative firms. Entry by innovative firms has positive net welfare effects, yet entry that simply duplicates the output of the incumbent monopolist has negative net welfare effects. Given the chronically low levels of profitability in liner shipping, this model would seem to predict that entry should be zero and price wars initiated to forestall entry will not occur. However, if countries subsidize their liner industry it increases the likelihood of price wars because it increases the likelihood of entry. This follows from the proposition that firms will price down to their marginal cost of production. But if the government subsidizes the production cost, the floor is lowered.

Officially sanctioned protectionism was supplemented by increased use of subsidies. All nations subsidize and protect their maritime industry to some extent. The United States retains the Jones Act, which protects United States flag carriers from foreign competition on coastal routes. Cabotage laws are a favorite of European policy as well. In addition, the United States government reserves its military and government cargoes for United States flag vessels only. LDCs have been notorious users of state subsidy in order to establish their own lines and often directly invest in national carriers.

The tremendous success of the Korean shipping industry, and more recently that of China, can in part be attributed to heavy state subsidy or direct state ownership of national carriers. The trouble with this non-market approach is that evidently, the expansion in liner capacity it has engendered has overtaken the contemporaneous growth in liner cargoes. Whether it is cargo reservation or direct subsidy, government assistance to its liner carriers distorts the market for capacity and can be a significant source of the insustainability of prices in any market that is or tends towards natural monopoly.

Although the comparison is imperfect, it may still be illuminating to compare sustainability conditions of maritime shipping with a similar industry - railroads.⁴² Both provide regular transport service on a fixed schedule, require large fixed cost to variable cost ratios, are subject to network effects and variable demand and were recipients of large government subsidies early in their history. Several studies have shown increasing returns to scale in rail transport.⁴³ The elasticity of cost with respect to output (measured in revenue-ton-miles) was consistently found to be below one. Hence, in all relevant respects, the rail transport industry can be described as tending towards natural monopoly. Consequently, competition is often destructive and socially wasteful.

In its earliest configuration, the United States railroad industry was the recipient of heavy government subsidy which sought to capture the positive externalities from the establishment of a national network of rail lines for both freight and passenger traffic. While subsidies helped the network expand rapidly, they also encouraged rapid entry (and

⁴² The imperfection lies in the flexibility of capacity as discussed in Chapter I. Capacity in railroads is more flexible than ocean shipping since railroads can adjust the number of cars on each trip.

⁴³ See Clark (1923), Griliches (1972), Brown, Caves, Christensen (1979), Hasenkamp (1976) and Spady (1979).

not necessarily efficient entry), overbuilding and excess capacity.⁴⁴ The industry made attempts to form rate-setting cartels in order to control what had become destructive competition, but these were plagued with cheating, and rate wars became commonplace. Together with the variability of demand and high sunk costs, subsidies helped create the ideal conditions for destructive competition. Where there were dozens of Class I railroad carriers before World War II, today there remain just four. In liner shipping, the same scenario appears to be emerging. Heavy state subsidy has helped bring about excess capacity, which has driven down freight rates, lowered returns on investment and ultimately has sparked a wave of industry consolidation.

In this section, the theory of natural monopoly and its sustainability was discussed as it relates to liner shipping. In these two concepts, two potential sources of excess capacity are revealed. First, in natural monopoly markets, firms may over-invest in capacity to cover periods of high demand. Second, if more than one firm operates, the problem of dynamic capacity expansion could lead to excess capacity when incumbent firms are non-collusive. Finally, when sustainable prices do not exist, entry can cause excess capacity, *all else equal*. Further, if incumbents are aggressive defenders and do not collude with entrants then they may invest in excess capacity as an entry deterring strategy.

⁴⁴ Kolko (1965).

VI. Contestable Markets

This section summarizes the relevant literature on contestable markets and barriers to entry as it might apply to an analysis of excess capacity in liner shipping. The theory of contestable markets is relevant to a discussion of excess capacity, because by the strict definition of a perfectly contestable market, there are no profit opportunities for potential entrants and therefore, no net entry. The theory of contestable markets ignores strategic behavior because it assumes that the structural conditions of entry force incumbent firms to behave *as if* they were operating in a competitive market. There would be no reason in this case to investigate strategic, entry-detering excess capacity since in a perfectly contestable market no such actions can profitably exist. But the trouble with the contestable markets theory in describing real markets centers around its definition of a barrier to entry. The theory considers only structural barriers and implicitly discounts strategic behavior among incumbent firms. To illustrate, suppose that even while structural features of a given market render it perfectly contestable, there may be actions that incumbents can take to erect artificial barriers to entry behind which incumbents are free to pursue supra-normal profits. One might conjecture that it is just such a market where strategic entry-detering behavior is most likely to occur. The trouble with this argument, according to a strict reading of the contestable markets theory is that entry-detering behavior would have to occur repeatedly over time. Since this behavior is costly, it is likely that incumbent firms would prefer to accommodate the new entrant rather than invest resources to deter him. However, in liner shipping excess capacity has indeed persisted over time. If excess capacity is indeed an entry deterring

strategy it gives credence to the conjecture that in fact incumbents do play this strategy repeatedly. To sort this out requires a more detailed examination of the theory of contestable markets and how it may have been applied in other industries.

In Baumol, Panzar and Willig (1982), it is found that “in an industry characterized by sub-additivity of costs but no sustainable prices, freedom of entry threatens the viability of the monopoly. Baumol shows that entry, under these cost conditions, has undesirable social welfare consequences because extra costs created by new firms are likely to come out of consumer surplus. This runs directly counter to Bain’s (1956) theory that with increasing returns to scale, only a finite number of firms are viable in a natural monopoly, and that the knowledge of this is sufficient to preclude entry. Existing firms are then free to price whatever the market will bear.

Baumol’s *et. al.* result is known as the contestable markets hypothesis. A perfectly contestable market is one in which entry or the threat of entry is sufficient to force incumbents to maintain prices at marginal cost. Any price above marginal cost invites entry and the subsequent competition drives price down to marginal cost. This result holds even if there is just one or a few firms serving the entire market. The theory is truly revolutionary in the context of traditional thinking about monopolies because it implies that the threat of entry is sufficient to force incumbents to price output at competitive levels. There is no need in this case for regulatory oversight of concentrated industries or even monopolies since the market is governed by competitive forces to produce the socially desirable outcome.

For the theory of contestable markets to hold in a given market, the absence of entry and exit barriers of any kind is required. In other words, there must be free entry

and exit, implying no sunk or unrecoverable costs.⁴⁵ In a perfectly contestable market, entry and exit are not only free but can be instantaneous. Moreover, potential entrants instantaneously observe incumbents' pricing above marginal cost, implying no information asymmetries. These conditions allow for "hit and run" entry, that is, firms are assumed to enter and exit the market opportunistically.

The above conditions are structural as opposed to behavioral. They describe physical and tangible conditions based on a market clearing model of competition. This implies that there is no collusion among incumbent oligopolists in either the pre-entry or post-entry game. Strategic entry barriers, on the other hand, are behavioral responses to structural conditions governing entry and exit. For strategic-entry deterring behavior to exist in a market that is structurally contestable, an argument must be made that there also exists positive economic profits for incumbents in the post-entry game. Otherwise, if economic profits are bound by the theory to fall to zero, there should be no net entry and no strategic entry-deterring behavior. A market that is technically contestable must have price equal to marginal cost, and consequently, zero economic profits. In a static context, if there are zero economic profits, then it is impossible to make the case that strategic entry-deterring behavior occurs since the cost of this behavior cannot be recovered in the post-entry game. This reasoning breaks down if strategic entry deterrence behavior can be profitably repeated over time.

Strictly speaking, the theory of contestable markets rules out entry-deterring behavior. This is an important point because there is empirical evidence in the maritime

⁴⁵ Sunk costs are costs that cannot be recovered in the short run.

literature that liner shipping markets are contestable⁴⁶ and as such, if excess capacity is observed it cannot be the result of strategic behavior but instead must be a consequence of the peculiarities of supply and demand dynamics of the industry.⁴⁷ If excess capacity deters entry in this case, it is incidental to operations. What follows is a more detailed discussion of the assumptions required for the theory of contestable markets to hold and how those assumptions may not be met in liner shipping markets.

The contestable markets theory says little about strategic entry-detering behavior because as an extension of perfect competition, it implies that the market clears and economic profits are zero. When economic profits are zero, net entry should also be zero since there are no profit opportunities to exploit. But the theory of contestable markets relies heavily upon rigid and perhaps unrealistic assumptions about pricing behavior, costs and information. This is partly why Shephard (1984) dismissed the contestable markets hypothesis as a “theorist’s toy”. Baumol’s assumption, that potential entrants take incumbent prices as fixed, denies the dynamic aspects of pricing behavior. Firms do cut prices and even engage in price wars. They expend resources on advertising to differentiate themselves, and may even carry excess capacity as a means of imposing a credible threat of aggressive behavior in the post-entry game to firms contemplating entry. Thus, an investigation of a market with no sunk costs and low structural barriers may still reveal high price-cost margins if incumbents can profitably pursue strategies to erect artificial barriers to entry. In other words, a static determination of contestability based on structural conditions denies that potentially aggressive incumbents may find it to

⁴⁶ See Davies (1986).

⁴⁷ These “peculiarities” are discussed in later in the dissertation as part of the section on the empty core approach.

their advantage to erect artificial barriers, such as imposing excess capacity on the market to deny profit opportunities to entrants. In a dynamic setting, one would have to believe that this strategy can be repeated profitably *ad infinitum*.

It is important at this point to make the distinction between structural barriers to entry and artificial or strategic barriers to entry. Bain (1956) defined a barrier to entry as anything that allows incumbent firms to earn supra-normal profits without threat of entry. Tirole (1989) lists these as economics of scale, absolute cost advantages, product differentiation and large capital requirements. Of these four, economies of scale and large capital requirements are structural, that is, they constitute the tangible requirements of production. Product differentiation and absolute cost advantages are assets enjoyed by incumbents that are created by incumbents themselves, such as learning by doing or research and development in the case of the former and raising customer loyalty and goodwill in the latter case. As such, they may be considered artificial barriers. Limit pricing is another artificial barrier commonly referenced in the literature. In the limit price model, incumbents set prices that are less than the monopoly price but above marginal costs. Potential entrants are then constrained in their ability to cover the fixed costs of entry and may be deterred. In Salop and Scheffman (1983), dominant firms may have the option of “raising rivals’ costs” to deter entry.

Demsetz (1982) adds legal restrictions or property rights to the barriers to entry list. These may include patents, trademarks or copyrights. Baumol and Willig (1981) add the requirement that in order for large fixed costs to constitute a barrier to entry, those costs must also be sunk, that is, those costs must be unrecoverable in the short run.

According to this conjecture, as long as fixed costs are not sunk costs, some industries, even those that retain characteristics of monopoly, may still produce the welfare maximizing outcome in spite of a lack of regulatory intervention. Hence for Baumol and Willig, economies of scale do not necessarily constitute a barrier to entry. For Stigler (1968), economies of scale are not a barrier to entry either, as long as potential entrants have access to the same technology as do incumbents. Stigler's definition of a barrier to entry is that production cost that must be incurred by entrants but not by incumbents. What he is referring to is start-up costs associated with producing output in a given industry.

Baumol and Willig, however, do concede that incumbents can erect artificial barriers to entry in the event that the payoffs to entry deterrence are greater than the costs, including opportunity costs, of erecting entry barriers. When incumbents engage in this behavior they impose a social cost that increases as the cost of the artificial entry barrier rises. Gilbert (1989) explains that strategic action undertaken by incumbent firms to deter entry is a contradiction of the perfectly contestable market theory in that by imposing artificial barriers to entry, incumbents are free to earn monopoly rents even if structural barriers are low.

The works of Baumol, Willig and Gilbert make clear that there is a distinction between economic behavior that is undertaken with the explicit goal of entry deterrence, and behavior that deters entry but that is incidental to supply and demand conditions. The degree of contestability of that market should play a key role in this distinction. In other words, if the market has low structural barriers to entry, there is a higher probability that incumbents will engage in strategic entry deterrence, all else equal, as long as there are

positive economic profits in the post-entry game. If structural barriers to entry are high, that same behavior may be a waste of resources if it is directed specifically at deterring entry. Hence that behavior is more apt to occur for reasons other than strategic entry deterrence.

One more distinction should be made, that is, the difference between strategic entry deterrence and strategic deterrence of expansion or, to use the language of Caves and Porter (1977), “strategic mobility deterrence.” Strategic behavior need not be reserved for potential entrants but may also be directed at rival firms already operating, albeit on a small scale relative to incumbents, or in a separate but adjacent market.

Evidence of Contestability in Liner Shipping Markets

Despite the strenuous objections by Shephard (1984), that contestability is not valid in real markets, Davies (1986) describes the liner shipping industry serving Canada as being perfectly contestable according to the following three criteria:

- 1) entrant and incumbent are “symmetrically placed,” that is, they are subject to the same regulations, have access to the same technology and produce outputs of similar quality;
- 2) costs are not sunk (costless exit);
- 3) consumers are able to react to price advantages offered by entrants faster than incumbents can provide a matching price.

Using data from the Canadian trades during 1977-79, Davies's empirical work revealed that controlling for the number of existing lines, the size of the market was the most important determinant of entry. He also found that over the three years covered by the data, 30% of all conference carriers exited the industry while 27% of non-conference carriers left. Davies goes on to claim that entry need not have a price depressing effect on the market since the multi-product nature of liner shipping precludes the need for a new entrant to commit all capacity to liner cargoes. This is especially true if the new entrant begins services on a small scale using multipurpose vessels rather than fully cellular container vessels.

The application of contestable markets theory to modern ocean liner shipping markets has generated some controversy.⁴⁸ To a large extent, the arguments hinge on the definition of liner shipping capital and its mobility. If liner shipping capital is defined as just the vessel itself, then capital is probably mobile. The more mobile the capital is, the less likely it is a sunk cost and the more contestable is the market. However, if liner shipping capital is defined to include fixed land-side infrastructure such as lifting equipment, berthing, cargo storage space, and other physical assets then at least part of an investment in a liner shipping service is more likely to be a sunk cost. Moreover, incumbent firms may possess intangible assets such as customer goodwill that can present a significant barrier to entry to potential entrants. In this case, the market cannot by definition be perfectly contestable.⁴⁹ Some lessons in capital mobility can be drawn from

⁴⁸ See Pearson (1987) Zerby (1988) and Franck and Bunel (1991).

⁴⁹ The existence of sunk costs do not entirely rule out contestability. A market that requires partial sunk costs can instead be considered imperfectly contestable assuming that that market meets other requirements set forth by the theory.

airline markets. The belief in capital mobility (and hence contestability) helped to motivate the deregulation of airline markets in the 1980s.⁵⁰ The conventional wisdom among supporters of deregulation at the time was that because aircraft can easily and instantaneously migrate from one declining market to another, it would serve to discipline the pricing of incumbent carriers. Levine (1987) contradicts that conventional wisdom by pointing out several features of airline industry capital that should reduce its mobility. Vertical integration, hub and spoke systems, frequent flyer programs, the need to lease airport slots and so on present significant obstacles for potential entrants, and as a result create deviations from perfect contestability. In addition, Levine finds market conduct, such as the frequent occurrence of predatory pricing, and performance, such as high entrant casualty rates, that deviate from the outcome predicted by contestable markets theory. Finally, he explains using “new industrial organization theory” that the contestable market hypothesis is an “inadequate model” to describe airline markets.

Airline markets, like railroading, share similarities with ocean liner shipping. Hence, in the spirit of Levine’s contrarian view of airline market contestability, Davies’ application of contestable market theory to liner shipping can be similarly critiqued. While his analysis is initially persuasive, there have developed several features of the industry since his writing that may now invalidate his conclusions. First, since most liner trade in the late 1970s was between developed countries, the majority of liner shipping companies were of the OECD (Organization of Economic Cooperation and Development) nationality, regardless of the flag of convenience under which they operated. This made for a smoother regulatory regime under the general OECD code of conduct for liner

⁵⁰ See Levine (1987).

carriers. Today, the majority of liner trade is between LDCs and the OECD. In LDCs, rules governing liner business conduct are more diverse than OECD rules, and protection of national carriers appears to be an overwhelming objective for many countries.⁵¹ Therefore, Davies' first point, that entrant and incumbent are symmetrically placed, may not be as relevant in today's liner market since they may not be subject to the same regulations. Second, unlike the late 1970s, the minimum efficient scale of liner operations, particularly on the major east-west trade lanes (United States-Asia, Europe-Asia, United States-Europe) may now involve costs that can be classified as sunk. At the time of Davies' writing, the average size and speed of container ships on the major east-west trades was much smaller than those constructed in the late 1980s and throughout the 1990s and demand was just a fraction of today's volume flows. As a result, the capital commitments required in the 1970s were a great deal smaller than they are today. The difference does not lie in the prices for new vessels, which have not varied much since 1980. At that time, the cost of a new 3,000 TEU vessel, the largest size container ship delivered that year, was just over \$45 million. In 1995, the price was around \$50 million.⁵² These figures are unadjusted for inflation. Moreover, there are significant economies of scale in container ship construction. The per TEU cost of a container ship falls steeply from around \$23.50 in the smallest vessels, until it reaches a minimum at around \$10.00 per TEU at a vessel size of 3,500 TEUs.⁵³ But operating a viable liner

⁵¹ See Heaver (1991) and White (1987).

⁵² See Drewry (1996). The real price of new container ships and for that matter all seagoing vessels has declined considerably since the 1970s and early 1980s because of the rapid emergence of shipyards in labor abundant countries in Asia and Eastern Europe. Shipyards in Japan, Korea, and Poland held considerable advantages in labor costs and rules plus a significant currency advantage that North American and European shipyards were unable and are still unable to match. The German shipbuilding industry has survived only through massive state subsidy.

⁵³ Ibid.

service under present day demand conditions requires a significant increase in the number, size and speed of vessels in service. The larger the ship, the more limited is its mobility. Some markets simply cannot accommodate larger vessels either because of physical infrastructure limitations or insufficient demand. For example, the new so-called “mega-ships” are accommodated by large ports in Asia and on the west coast of the United States. Those same ships are in the present day, unable to call ports on the east and gulf coasts of the United States because of draft requirements.⁵⁴ Nor are they able to call any ports in Latin America, the Caribbean or several other markets. In addition, there may be other costs that are sunk, including cargo-handling equipment, warehouses, and other terminal facilities, as well as significant costs to establish goodwill with customers.

Given these costs, the risks to a potential entrant are significant. If a new carrier enters one of the major trade lanes successfully with capital of minimum efficient scale, but is subsequently driven from the market by inadequate demand, a price war, or some other exogenous but long-term factor, he faces costs that may be largely unrecoverable. First, depending upon the physical characteristics of the vessel, the option to redeploy the vessel to another more profitable trade lane may not exist. Land-side infrastructure constraints such as inadequate harbor depth, as well as limited demand make shifting a large vessel to a smaller north-south trade lane or an intra-regional service infeasible. Moreover, the specific nature of a container ship’s design makes it unsuitable for other shipping product markets unless a significant redesign or switching cost is incurred. The exiting carrier would have to rely on the market for second hand vessels, which, though

⁵⁴ Draft is a term used to describe the depth of the submerged portion of the ship. Most east coast United States seaports cannot support drafts of over 53 feet.

viable, does not guarantee to fetch the original cost. There may be an option to lease the vessel, to an existing carrier or through the charter market. In the event that demand has fallen steeply, however, it is uncertain whether the return from leasing or chartering could cover the fixed costs of the vessel. Once capital costs are incurred, therefore, and the trade lane is penetrated, those costs at least in part and under certain circumstances can in general be classified as sunk. As per Shephard, if just a small fraction of the start-up costs can be classified as sunk, then the industry cannot be classified as contestable.⁵⁵

As mentioned above, the changing level of technology has effectively raised the bar for minimum efficient scale. Vessels of 4,000 TEUs and above, the so-called post-Panamax class of ships, hold significant advantages over smaller vessels in unit costs on the major east-west trade lanes. At the present time there are several new vessels with nominal rated capacities of 6,000 TEU and above working the east-west trades.⁵⁶ Thus, for an entrant to compete successfully on these lanes, his capital commitment must necessarily match, at least in part, the technology of incumbents. To circumvent this constraint, carriers may have the option of entering the trade through a vessel sharing arrangement, which would allow them to carry cargo on a partner's vessel in exchange for making space available on their own vessels in some other trade lane. In this way, a carrier can avoid the need for an immediate commitment of tonnage. This would necessarily be a small-scale entry, however, and would have virtually no effect on the pricing behavior of incumbents.

⁵⁵ With respect to liner shipping, second-hand vessels may sell for downwards of 10% of their original value. In the early 1990s, US lines, a major United States flag carrier folded, after which its large "Econships" sold for just a tenth of their acquisition cost.

⁵⁶ East-west trades refer to U.S.-Asia, U.S.-Europe and Europe – Asia.

Davies' third point, that small changes in price have large effects on demand, is also open to criticism. Although information on pricing is readily available and could potentially cause large shifts in demand, Davies' conclusion relies heavily on the presumption that liner shipping is devoid of product differentiation. This conclusion is probably outdated. In the 1970s containerization was still relatively new and container ships less technologically evolved than they are today. Moving a TEU from point A to point B was generally a standardized process with little difference in quality among firms. This may no longer be the case. In addition to overall service characteristics and customer loyalties, there do exist ample opportunities for significant product differentiation among liner shipping carriers. In the modern liner industry, technology has made such attributes as refrigeration available for containers, faster service speeds at less cost, and consulting services to help with inter-modal, land-side transport, and logistics. Several niche markets have developed by commodity or by origin-destination pairs. For example, carriers may specialize in the transport of wines or other temperature-sensitive perishables. Or they may be specialists in navigating through a particularly difficult transport rules environment such as persists in many developing countries. Since product differentiation can play a large role in raising barriers to entry, Davies' conclusion that price competition makes the industry contestable may be suspect.

Davies's argument assumes that capital in liner shipping is completely mobile. Under this assumption, a carrier operating in a separate market can easily shift his equipment to enter another. Yet liner shipping is a committed service with schedules announced far in advance. To shift his capital without purchasing or leasing new equipment, the entrant would have to cancel his current service. This can have adverse

reputation effects and reduce the entrant's chances of success in the new market. And like Levine's depiction of airline markets, the need for physical land-side infrastructure and customer goodwill presents obstacles to capital mobility.

Finally, when Davies published his analysis, long-term confidential contracts were in general, illegal under the OECD rules governing liner conferences and thus he ignored the issue. However, OSRA of 1998, now permits this practice, partly in the name of economic efficiency. This practice may also have significantly altered the ease of entry into liner shipping. The length of contract and provisions for breach holds demand captive while the confidentiality of the agreement reduces the probability that an entrant will choose a price that will induce the demanders to switch. The incumbents are thus in a position to foreclose on potential rivals and substantially reduce the contestability of the market. Aghion and Bolton (1987) find that in a model of duopoly with asymmetric information, contracts constitute a barrier to entry when the post-entry profits of incumbents in the absence of any contract are lower than pre-entry profits. Further, although it is not socially optimal to eliminate entry through contracts completely, contracts can reduce inefficient entry and reduce socially wasteful switching costs. Focusing specifically on the liner shipping industry, Yong (1996) finds that exclusive dealing contracts are particularly burdensome to potential entrants when the entrant is capacity-constrained relative to demand requirements. That is, when there is a minimum efficient scale that makes a firm viable in a market, a capacity-constrained entrant will find it difficult to generate sufficient demand to make entry profitable. Yong's model makes the key assumption that capacity is exogenously given and cannot be changed, at least in the short run. This may not apply to the liner shipping market where capacity is

readily available on the second-hand or leasing market. In this respect, the second-hand and leasing market alternatives level the playing field for a potential entrant such that it eliminates the risk associated with the 2-3 year process of ordering, purchasing and deploying capacity. It enables a potential entrant to lock in demand before deploying new capacity, despite the use of long-term contracts by the incumbents. Were customers to acknowledge that entrants can provide immediate and low cost service, they may not, as Bork (1978) suggested, ever sign a long-term contract. On the other hand, incumbents recognizing that the second hand market poses a threat may seek to hold their own out-dated capacity in reserve to shorten the supply of second hand vessels.

Sjostrom (1988) investigated the effects on entry of loyalty contracts, now illegal in all United States ocean trades. He found that because the demand for frequency of service is downward sloping, the entrant, such as a tramp service, will be excluded if he cannot provide a sufficient level of service frequency. A rival liner (as opposed to the tramp) is far less likely to be constrained in frequency and will not be deterred by loyalty contracts. Hence, only if the incumbent can expand capacity at lower cost than the entrant will the monopoly be sustained. Sjostrom's analysis can be extended to the current contracting regulations because both loyalty contracts and long-term confidential contracts permitted by OSRA require long-term commitments on the parts of supplier and demander. Long-term contracts reduce incumbent risk and thus reduce costs of adding capacity, while simultaneously preempting potential entrants. Long-term contracts may provide incentive to incumbents to expand capacity because in effect, both the shipper and the carrier share its costs.

So far, none of the research on contestable markets in liner shipping has investigated the effects on entry of vessel sharing agreements and alliances among incumbents. One could presuppose that in order to deter entry, incumbents could collude to deny space on their vessels or refuse to share land-side equipment to potential entrants. Subsidies are another important consideration left out of the analysis. A firm being subsidized by a government body determined to extract the economic rents and positive externalities associated with liner shipping could conceivably overcome any incumbent firm's attempt to protect its market.

VII. The Empty Core Approach

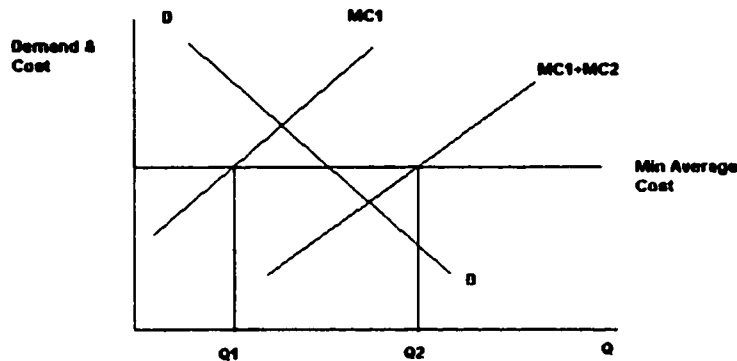
As was made clear in the preceding chapter, what may appear on the surface to be strategic entry-detering behavior may instead be an artifact of the economics of a particular market. To distinguish between strategic and normal operating behavior in a given market requires a thorough understanding of the conditions that incumbent firms face in their operations. With respect to excess capacity, one explanation for its existence other than strategic entry deterrence may be found in the empty core approach.

Edgeworth developed the empty core approach, often referred to as the integer plant problem, in the late 19th century. It was long ignored by economists until Telser resurrected it as a valid means of characterizing some imperfectly competitive markets. This section provides a review of the relevant literature on the theory of the core and what it may foretell about excess capacity.

In a market with large fixed costs, avoidable costs, indivisibilities, or network effects, unrestricted competition cannot bring about a stable outcome. Telser (1996) describes the world of perfect competition as occurring only under two broad conditions. First, the aggregate industry production function must be super-additive, meaning that the sum of individual firm outputs must be greater than or equal to the outputs in markets that do possess a competitive core. Second, the aggregate industry production function must exhibit non-decreasing returns to scale. These conditions are less likely to be found in industries that require high fixed costs relative to variable costs. Steel, cement, aluminum, public utilities and transport, all of which require large fixed costs, are a few examples of industries where the lack of a competitive core may prevent an outcome, such that supply equals demand at every point in time. Under these conditions, the total costs resulting from the competition for factor inputs rise above total revenue. In these markets, no firm can survive where more than one firm operates and we can expect firms to take measures that restrict competition. The similarities to the theory of natural monopoly are obvious. Cost, demand and supply conditions can render competition destructive and socially wasteful.

Bittlemeyer (1988) explains what he calls the “fundamental and long-recognized instability” in a classic market model within the context of Viner industries where all firms possess identical U-shaped average cost curves. Figure I below illustrates this concept in its simplest diagrammatic form.

Figure I. Diagrammatic representation of the theory of the core.



Suppose there are two plants that face a downward sloping demand curve such as DD in Figure I above. Suppose further that marginal cost is a discontinuous function of total industry output such that the addition of one firm shifts the marginal cost schedule to the right. Bittlemeier showed that when one firm operates in this market, price lies above average cost at the intersection of MC1 and DD, and the firm earns positive economic profits with the consequent loss in social welfare. If another firm enters, he drives price to marginal cost (the intersection of Min Average Cost and MC1 + MC2), but given the presence of high fixed costs, this may lie below total average costs (the intersection of DD and MC1 + MC2), and each firm operates at a loss and with excess capacity. Again, from a total welfare standpoint, this market configuration is inefficient. If one firm then shuts down, the remaining firm operates again as a monopoly making supra-normal

profits. Supply to the market will fall, with a commensurate loss in surplus. Now the idle firm has incentive to undercut the monopolist by offering a price just an epsilon below the active firm. This competition will recreate the inefficiencies of two firms and the configuration is unstable. No competitive equilibrium exists in this market and it is said that the core of the market is empty. If the two firms are allowed to cooperate, however, a completely different picture emerges. This is discussed in more detail below.

Markets that lack a competitive core achieve efficient equilibrium only when cooperative behavior is permitted. A cooperative agreement on the supply side could solve the instability by allotting shares of the market to participants and/or fixing prices at levels consistent with average costs. Such an agreement, although it appears on the surface to create a cartel, does not necessarily do so. A cartel by definition wields market power sufficient to earn supra-normal profits for its members over time. But a truly effective cartel is dynamically stable. Its members must be assured that their incentive to cheat is outweighed by the costs of cheating. This is not always the case. Porter's study (1981) of the Joint Executive Committee (JEC), a supposed cartel that governed pricing in the United States railroad market between the east coast and the mid-west during 1880-86, was plagued by frequent cheating, and that cheating was a significant determinant of price during that period. The agreement was formed because of persistent excess capacity on the westbound leg of the route, and was structured in every way like a cartel arrangement. However, the frequent occurrence of cheating and its significant impact on pricing casts doubt on whether the JEC actually operated as a cartel. According to Telser (1987), frequent cheating disqualifies the arrangement as a cartel and another explanation for its existence must be found. Telser claimed instead that the core of the U.S. east coast

and the mid-west railroad market was empty and that the JEC was an efficient response to that emptiness.

The most salient difference between the empty core and natural monopoly approaches to describe the failure of a market to reach a competitive equilibrium lies in the definition of the average cost function. It is assumed in natural monopoly that long-run average costs are falling for the entire range of output. In the above example, costs only fall over a certain range of output, after which the function forms the familiar U-shape. In liner shipping, the average cost curve will depend almost entirely on the capacity of the vessel, the cost of fuel and the cost of loading and unloading facilities. As the ship is loaded, each additional unit of cargo reduces the unit cost of the upcoming voyage. Once the maximum load factor is reached, however, any additional cargo would cause a discrete jump in the cost curve, after which costs of transporting cargo on that vessel become infinite. Hence, if we ignore diseconomies at loading and unloading facilities, the average total cost curve in liner shipping is not U-shaped but exhibits a discontinuity at the maximum range of output per vessel. In a very unbalanced trade, long-run average costs are also heavily influenced by the transport of empty containers. Estimates are that up to \$3 billion per year is spent by carriers in repositioning costs.

Another important distinction between natural monopoly and the empty core relates to the indivisibility of supply and the divisibility of demand. Sletmo and Williams (1981) imply that the core of liner shipping markets is empty because of the inherently unstable market structure brought about by the peculiar nature of supply and demand in the industry. The need to achieve profitable load factors in the high fixed cost environment while adhering to a set schedule can lead to destructive competition when

there are too many firms serving a particular trade route. The problem is typical of all scheduled transport such as rail, air and motor except that in ocean liner transport, “the unit in which the service is produced is much larger in relation to total annual traffic volume than the units in which [air, rail and truck service] is produced.” This inflexibility or indivisibility of productive units can cause a relatively large degree of under-utilization and thus reduce profits on every voyage. Davies (1983) concurs, writing “...it appears that in liner trades, we have a total situation where profits and unit costs are highly sensitive to the degree of capacity utilization, where both fixed and [variable] costs are relatively high, where capacity is extremely difficult to reduce and *where capacity increments are subject to great indivisibilities.*”

In the absence of legally sanctioned cooperative behavior, how do firms facing an empty core market make production decisions? In his 1977 paper, Sharkey states, “...for decreasing cost industries, the optimum capacity depends critically on the rate of growth and variability of demand.” Sharkey makes two key assumptions that fit the liner shipping industry well. First, that demand varies with a periodic component which accurately describes the seasonal impact of container trade. Second, that the costs of building capacity exhibit economies of scale. A study by Drewry (1996) shows, empirically, that the unit cost of building a container ship falls significantly with the size of the ship. Sharkey shows that under these conditions, there is no optimal plant (vessel) size, and that the pursuit of efficient production forces the firm to “...sacrifice economies of scale in order to achieve greater flexibility through a larger number of plants.” Again, this condition can lead to excess capacity. Moreover, if two or more firms serve the market, these conditions are likely to produce instability of market structure.

Evidence of an Empty Core in Liner Shipping

There is to date no rigorous and definitive method available for testing the status of the core in a given industry. Instead, researchers have to make inferences based on the presence or absence of specific features that are associated with an empty core. For example, industries that face a low elasticity of demand, variable supply and consist of just a few firms might suggest an empty core. The theory of the core says that if these conditions prevail, collusion may exist to fill an empty core rather than to form price-making cartels. If the industry were in a prolonged slump, then collusion would also follow the core model rather than the cartel model. On the other hand, collusion in industries with heterogeneous supply functions would indicate the cartel model.

According to Bittlemeier's interpretation of Viner industries, markets with empty cores prevent an efficient matching of supply and demand. When just one plant operates, prices rise above average costs and the supplier makes supra-normal profits. When two firms operate, the sum of marginal costs lie below minimum average costs and both firms incur a loss. If in the first instance, one firm is able to bargain with a supplier for all the market, then he can drive the rival firm from the market. But then the configuration returns to the high price equilibrium in which a newcomer can undercut the incumbent in the same manner. The implication is that market shares should be very unstable over time. In addition, if those firms that are under threat are the recipient of subsidies, either through a government entity or from profits earned in some other market, they will likely continue to operate but with a high level of excess capacity. Applying this principle to liner shipping markets should result in the following proposition. If the liner conference

is an effective response to core emptiness, then it should show a relatively high level of market share stability and relatively lower levels of excess capacity compared to independent or non-conference members. Instability should increase on trade routes or in time periods when conference share is relatively low.

Pirrong (1992) and Sjostrom (1989) have both tested the empty core model of Telser (1978) in ocean shipping markets. Both papers dismiss the notion that liner conferences operate as rent earning cartels but instead exist exclusively to stabilize market shares and freight rates. The argument does have merit. The cartel model should produce supra-normal profits over time. Yet conference members in the aggregate have failed to achieve even normal rates of return on investment by global standards.

In Pirrong, the focus is on the divisibility of demand and the indivisibility of costs and supply. Using data gathered from one ship line, he estimates a total cost function and finds evidence of production non-homogeneities that suggest an empty core in liner shipping. Because of the lumpy nature of liner shipping capital, market conditions often force liner carriers to add capacity in larger increments than is required to meet demand. This creates avoidable costs⁵⁷ in which marginal costs are discontinuous at capacity. The additional capacity creates the empty core. Pirrong's model, however, is unclear about how the empty core model differs from the natural monopoly. Pirrong found increasing returns over the entire range of output, which is consistent with natural monopoly. Part of this may have resulted from the use of a limited sample of vessels, which were generally

⁵⁷ The term "avoidable cost" is used interchangeably with incremental cost. It is the cost avoided by not providing a particular service given all of the other costs involved with providing that service.

smaller on average than the average size of vessels plying United States trade lanes and unlikely to encounter diseconomies associated with stevedoring at seaports.

Sjostrom also finds evidence that supports the theory of the core in liner shipping markets. He used liner conference output, demand variability, value of commodities shipped, and dummies for legal entry restrictions. However, the data set employed by Sjostrom was also limited in scope. Sjostrom's conference market share had to be estimated from shipping schedules and may not have truly reflected actual conditions. He also made the key assumption that entry costs are sunk. The presence of sunk costs can rectify an empty core problem since they preclude hit and run entry.⁵⁸ As explained in Chapter VI, the issue of whether liner shipping costs are sunk costs is unresolved. Both Sjostrom's and Pirrong's data sets were of limited geographical scope and time horizon. These limitations are important since empty core markets may develop and disappear over time and geography depending on the conditions of firm behavior and regulatory restraints within those particular markets. If excess capacity is evidence of an empty core then there should be a random component added to the model to account for the probability that during a particular time interval or in a particular market, supply may meet demand. Moreover, neither author addressed the economic consequences of empty core markets, such as dynamic market share or freight rate instability, but instead focused solely on conditions that may identify markets with empty cores.

Based on Pirrong's cost function approach, Button and Nijkamp (1999) have also done empirical work in the theory of the core. In a study of the European airline industry, one which shares similar characteristics with ocean liner shipping, they found evidence

⁵⁸ See Reitzes (2001).

(though not conclusive) that the increasing number of collusive arrangements among carriers serving European markets was due to cost, demand and supply conditions that prevent the formation of an economic core. Their econometric specification used proxies that attempted to capture the conditions listed above that should indicate the objective of collusive agreements. Specifically, the authors included distance between airports, number of firms on the route, potential charter competition, total flights, average load factor and the coefficient of variation of demand to explain the market share of the domestic carriers serving routes that included the home country of the carrier.

The above studies suggest that excess capacity is central to the test for an empty core. But there is an issue of causality. Markets with empty cores do exhibit excess capacity but excess capacity, perhaps due to inefficient entry or expansion, is also an important element in the creation of an empty core. In addition, while excess capacity may exist in the physical sense, if the costs of that excess capacity can be shared through cooperative agreements among suppliers and demanders, then the mere existence of excess capacity may not tell the entire story of the status of the core.

There is one thing for certain that can be deduced from previous work on the status of the core in ocean liner shipping and air transport. That is, if the core of a market is empty, then by the accounts given above, an increased level of cooperation amongst the market players should relieve problems of supplier and freight rate or fare instability that are endemic to markets lacking a competitive core. An empirical test of the theory of the core to modern ocean liner shipping markets must therefore take into consideration the increased level of vessel sharing arrangements and strategic alliances. At the time Pirrong and Sjostrom conducted their analysis, there were very few liners engaged in

vessel sharing partnerships or alliances and that lack of cooperation in managing capacity may have contributed to their findings that liner market cores are empty. These arrangements, which became pervasive in the 1990s, have probably done much to solve the problem of the empty core. Incumbents involved in these relationships were not bound to provide their own capacity when demand overtook supply. Instead, the excess demand could be easily shuttled to a partner's vessel, precluding the requirement to deploy an additional vessel that would likely suffer from low rates of capacity utilization. Conversely, in a downturn, a vessel operating at low levels of capacity utilization can be taken out of rotation if a partner's vessel with empty space can be used to accommodate the demand that still exists.

VIII. Technical Change

A full analysis of the potential sources of excess capacity in liner shipping cannot ignore the issue of technological change. Stiglitz (1987) states "markets in which technical change is important are never perfectly competitive." Technical change can produce the increasing returns that render competition unworkable. Posner (1969) suggests that in a market that once supported several firms, "imperfectly anticipated technological change" could bring about a natural monopoly before several firms have time to make "graceful exits." In this situation, if competition is unregulated, the most efficient firm will survive and the other firms fail, or are acquired by the survivor. The introduction of containerization in ocean liner shipping was just such an innovation.

Posner also envisioned a second outcome whereby the existing firms adopt a “live and let live policy” with each colluding to refrain from competition and resulting in inefficient operations. On the surface, this appears to be the function of liner shipping conferences.

Technical Change in Liner Shipping

If the advent of technologically advanced ships, ports and logistics was imperfectly anticipated, then Posner’s second conclusion more aptly fits the liner shipping industry. In part, this is a consequence of the desire among governments to keep and maintain a sufficient shipping industry for reasons already outlined. Collusion is tolerated and even encouraged through the policy of antitrust immunity in order to insure against a weakening of sea power.

Since containerization, the maritime industry may seem to be an unlikely source of technological change. Yet technological innovations in engine design, hull design, navigation and land-side equipment have dramatically and rapidly increased output per unit capacity and reduced per unit manning requirements. Conference carriers compete with independents and tramps largely by offering more frequent service. This requires both large capacity and speed. Hence the size and speed of container vessels, both of which have increased significantly over the past ten years, can be used to measure technical change in liner shipping. In United States trades during 1991, the average size of a container ship on a major east-west route was 2,611 TEUs traveling at an average service speed of 21.0 knots. In 1999, the average vessel size on these trade lanes had

grown to 3,198 TEUs with an average service speed of 21.9 knots. Vessels have in addition become slightly more fuel efficient, consuming 0.032 tons of bunker fuel per TEU per day on average in 1991 and 0.031 tons in 1999. The largest vessels afloat now can load upwards of 6,000 TEUs and expectations are that within the next decade, vessels of over 8,000 TEU capacity will be in service. In fact, given that new engine technology can deliver upwards of 90,000 horsepower, there is virtually no technical limit on the future size of container ships. What does limit container ship design is land-side facilities and harbor depth. In the United States, only such ports as Los Angeles and Long Beach are currently deep enough to accommodate the draft requirements of the new generation of mega-ships.⁵⁹ These diseconomies are enough to erase some of the scale economies gained when the ship is at sea. In addition, mega-ships also impose limits on routing flexibility. For example, since they are too large to fit through the Panama Canal, carriers serving the United States East Coast from Asia have to make use of the Suez Canal, a longer and more costly route. Tables II through IV present some statistics for fully cellular container ships serving United States trades lanes for 1992, 1996 and 1999.

Table II. Average rated capacity of container ships by trade lane.

Trade Lane	Average Rated Capacity (in TEUs)		
	1992	1996	1999
North Europe	2,533	2,821	3,057
The Mediterranean	2,135	2,223	2,860
West Coast South America	1,033	1,190	1,711
Oceania	1,201	1,226	1,427
Trans-Pacific	2,573	2,978	3,254
Mideast/Red Sea	2,552	2,944	3,835

⁵⁹ Mega-ships is a term used in the liner shipping industry to describe vessels of 6,000 TEU capacity and above.

Table III. Average rated speed of container ships by trade lane.

Trade Lane	Average Speed (in Knots)		
	1992	1996	1999
North Europe	20.2	21.0	21.5
The Mediterranean	20.0	20.0	21.4
West Coast South America	17.6	18.4	19.0
Oceania	18.6	18.2	18.7
Trans-Pacific	21.2	21.8	22.1
Mideast/Red Sea	20.3	21.6	23.1

Table IV. Average rated fuel consumption of container ships by trade lane.

Trade Lane	Average Fuel Consumption per TEU (in tons per day)		
	1992	1996	1999
North Europe	0.030	0.035	0.032
The Mediterranean	0.041	0.035	0.029
West Coast South America	0.039	0.037	0.036
Oceania	0.053	0.048	0.043
Trans-Pacific	0.034	0.034	0.032
Mideast/Red Sea	0.030	0.030	0.031

Technical change can certainly lower unit costs of production, but how does this cause excess capacity? If capacity is introduced without scrapping of older vessels and without a commensurate rise in demand, then of course, excess capacity will be the result. Container ships in general have a service life of 25 years. Technical change has no set schedule, however, and it is unlikely the technology becomes available just when a fleet reaches its turnover time. Moreover, carriers that deploy the larger vessels gain a unit cost advantage over rivals and potential entrants, compelling the latter to increase the size of their ships as well. Absent coordinated action, a race to deploy the largest vessels may emerge, the winner of which will gain market share at the expense of rivals with lesser technology.

Although the distinction is not entirely clear, technical change in liner shipping is probably more “technology-push” rather than “demand-pull.” Steam ship lines do not, as a rule, directly engage in research and development. They may instead be active in providing grants to various marine and naval engineering research institutes. As such, the diffusion of new shipping technology can be rapid, as there is little in the way of proprietary information among lines. Shipping technology is freely available to all market participants, the only constraints being the capital requirements to possess it.

IX. Other Sources

Other sources of excess capacity in liner shipping involve macro-economic variables that affect demand for ocean transport services. Variables that indirectly affect international trade, such as national incomes, industrial production and developments in trade policy should also indirectly impact the supply of ocean transport services. All of these need to be accounted for to arrive at an accurate depiction of capacity choice.

In addition to macroeconomic factors, we have thus far described three potential sources of excess capacity in liner shipping outside of the strategic argument. To sum up, in the natural monopoly case, excess capacity can be the result of the need to keep reserve capacity on hand to cover spikes in demand, or may also result from the problem of dynamic capacity expansion. In markets with empty cores, excess capacity is endemic since there can be no efficient matching of supply with demand. Finally, technological change can create excess capacity if old capacity is not scrapped or redeployed, or if

technological change introduces a race to put the largest, most cost-efficient ships in service.

Having summarized the potential sources of excess capacity, the next sections begin the theoretical development of an econometric model to explain excess capacity in liner shipping markets as a function of strategic incentives as well as variables that approximate natural monopoly, an empty core and technical change. It begins with a review of the literature on strategic motivations of excess capacity and summarizes the important empirical work undertaken. A model of excess capacity as a strategic entry deterrent is then introduced, followed by an analysis of how this action may affect the dynamic stability of liner shipping markets.

X. Capacity Choice Models

Spence (1977), Dixit (1980), Eaton & Lipsey (1982), Gilbert and Harris (1984), Kamien and Schwartz (1972), Bernheim (1984), Gilbert and Vives (1985) and Gaskins (1971), among others, have all considered the problem of capacity choice in oligopolistic or decreasing cost industries. A common theme that runs through each of these papers is that the behavioral perceptions about incumbents can alter potential entrants' decisions. In other words, to successfully deter entry, the incumbents' threat to increase output and intensify competition in the post-entry game must be credible. The role of excess capacity is to make that threat credible. Spence assumes that existing firms choose to hold excess capacity as part of an entry-detering strategy. The excess capacity allows firms to respond immediately with increased output and lower prices when entry is

threatened, thereby decreasing the probability of entry by reducing the prospects of potential entrants. A strategy of holding excess capacity differs from the limit price model in that production is necessarily inefficient. Prices are higher than the limit price, and output is lower. However, existing firms that are tacitly colluding will likely find that monitoring each other's capacity is easier than monitoring each other's price. With deviations easily revealed, existing firms are better able to maintain stability.

Dixit concentrates on the subtleties of competitive interactions between incumbent and entrant. Such matters as the reputation of the incumbent can influence the decision to enter the market. Heavy pre-entry investment can signal potential entrants that the incumbent, having incurred large capital costs will be an aggressive competitor post-entry. In Dixit's model, capacity expansion costs may be an important determinant of an incumbent's reaction function when faced with a credible entry threat. He finds that unlike in Spence, capacity expansion costs limit the range of incumbent action, and at some threshold level, incumbents' threats to saturate the market with their own capacity becomes non-credible.

In Eaton and Lipsey, entry deterrence hinges upon the "ability of incumbents to create irreversibilities." They describe two types of entry: predatory, where the incumbent is replaced by the entrant; and augmenting, where the incumbent accommodates the entrant. The type of entry is hypothesized to result from the nature, i.e. the durability, of product-specific capital investment. If capital is "immortal" and is product-specific, i.e., has no use other than that for which it was originally intended, then entrants perceive it as an irreversible investment and an eternal commitment to production. Entry in this case, if it occurs, will be augmenting, since the incumbent's

commitment to immortal capital is sufficient to convince the entrant that an aggressive posture would be fruitless. Incumbents do not hold excess capacity in this case. On the other hand, if capital decays, then the commitment by the incumbent must be renewed periodically. In this case, entry is more likely to be predatory, where the entrant replaces the incumbent. Knowing this, the incumbent deters entry by holding excess capacity, denying the entrant a positive stream of discounted profits.

In Kamien and Schwartz, incumbent uncertainty of the timing of entry can lead to persistent excess capacity and marginal costs below marginal revenue in a dynamic setting. The analysis relies heavily on the assumption that once deployed, capacity is inflexible. Gaskin (1971) considers a dynamic model where incumbents maximize long-term profits, and entry occurs at a constant rate. Entrants cause the price to fall gradually to the limit price, and unless the incumbent has a cost advantage, his share of the market is driven down to zero.

In a model with increasing returns to scale, growing demand and lumpy additions to capacity, Gilbert and Harris imply that excess capacity can occur when incumbents follow a strategy of preempting potential entrants by adding new plants. Preemption resembles Bertrand competition and implies earning negative short-term incremental revenue on new plants (excess capacity), and reduced revenues of existing plants. However, if the potential entrants and incumbents compete in a Cournot–Nash fashion, then excess capacity does not exist because firms always earn positive profits somewhere between the competitive outcome and monopoly. The difference lies in the ability to affect decisions of rivals. In Cournot-Nash equilibria, firms behave, taking rival behavior as given. If firms undertake investment to preempt rivals, it suggests that they believe

their rivals' behavior can be governed by their own. Thus in a Cournot-Nash game, a preemptive investment would have no affect on an entrant's decision to enter or not. Capital accumulates faster in a preemptive strategy and excess capacity can occur.

In the broadest sense, Schumpeter's thesis (1942) denies that incumbent firms would undertake any action to defend their market against potential competitors because the continuous process of innovation in capitalist economies - Schumpeter's theory of "creative destruction" - makes any investment in entry deterrence an exercise in futility.⁶⁰ He wrote, "...the impact of new things - new technologies for instance - on the existing structure of an industry considerably reduces the long-run scope and importance of practices that aim, through restricting output, at conserving established positions, and at maximizing the profits accruing from them."⁶¹ Schumpeter made no distinction between mature industries, such as liner shipping, and immature industries. Both are implicitly assumed to face the same threat of technological innovation that will undermine the monopolist's dominance.

With respect to excess capacity, Shy (1995) denies that it can be a successful entry- deterring strategy. His conclusion relies heavily upon the assumption that the costs of increasing output above the equilibrium level of capacity, is prohibitive. Moreover, Shy's model assumes that capacity is irrevocable. In his two-stage game, the incumbent costlessly chooses a capacity level in stage one. In stage two, both entrant and incumbent choose output levels and play a Cournot game. Because the cost of increasing output

⁶⁰ Schumpeter's theory of creative destruction is an apt description of the dramatic changes undergone by the liner industry after the advent of containerization in the late 1950s. Containerization so lowered the fixed costs of liner operations that it induced entry on a large scale and forced incumbents to adopt the new technology almost immediately.

⁶¹ In "Capitalism, Socialism and Democracy," Chapter VIII, page 87.

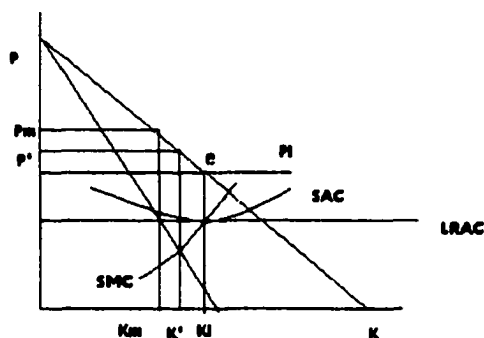
above planned capacity is prohibitive, and the entrant is aware of that, the threat by the incumbent to do so is not credible and the strategy will fail. Benoit and Krishna (1991) go even further. They suggest that in a dynamic setting, excess capacity may even invite entry, because commitments, such as excess capacity that imply predatory behavior are as just as likely to increase the prospects for collusion in the post-entry game. They conjecture that excess capacity that is sufficient to deter entry by “pessimistic firms” will also invite entry by “optimistic firms” who believe that the incumbent will be unwilling to sustain repeated losses and will offer to accommodate the entrant instead. The probability of accommodation increases if there is a history of cooperation in the industry and if there are high exit barriers or sunk costs.

Models like that in Spence, where oligopolies hold entry-detering capacity, implicitly assume that the oligopoly is a “shared monopoly”, that is, individual oligopolists behave in a purely cooperative fashion and share total industry profits among themselves. The strategy is likely to break down, however, if the oligopolists behave non-cooperatively. In this case, a “free rider” case emerges, since entry-detering capacity takes on the characteristic of a public good. Bernheim (1984) and Gilbert and Vives (1985) show that the free-rider problem is a function of the degree of certainty regarding the amount of investment required to deter entry and the level of cooperation among the incumbent oligopolists. When the amount of entry-detering capacity is certain the free rider issue is unimportant, because regardless of which incumbent does the investing, the returns to the oligopoly are infinite. In each model there exists a critical threshold of investment that determines whether entry occurs or not. An epsilon of investment above the critical threshold limits entry to zero. If entry occurs, returns to the oligopoly are

driven down to zero. If entry is deterred, returns are infinite. Therefore, it doesn't matter which incumbent undertakes the investment, since the choice is either zero returns or infinite returns. However, Waldman (1987) shows that the free rider issue can reduce optimal entry-detering investment when the level of entry-detering capacity is uncertain. In this case, the question becomes, which incumbent does the investing in excess capacity? If incumbents behave in a purely cooperative fashion, then excess capacity can be allotted to each and there is no free riding. On the other hand, if the incumbent oligopolists behave non-cooperatively, and the amount of entry-detering investment is uncertain, then it is unclear if any of the incumbents will opt to deter entry. Doing so, first, does not guarantee entry deterrence (uncertainty), and second, its investment is a return to rival incumbents (the public good aspect).

Wenders (1971) illustrates a convincing argument that if incremental costs of increasing output during periods when entry is threatened are sufficiently low to maintain profitability, excess capacity may be an important tool to prevent entry. The argument has appeal for liner shipping because liner shipping, for most of its range of output, is a decreasing cost industry. Once the threat of entry is revealed, it is relatively easy for the incumbent carrier, operating a multiple vessel service with excess capacity on a particular route at a particular frequency, to increase its output by simply loading more cargo per vessel, or increasing the frequency of its voyages. The diagram below is Wenders' illustration of his concept. In it, it is assumed that long-run average costs and long-run marginal costs are constant. Short-run average costs are U-shaped and short-run marginal cost is upward sloping and intersects the average cost curve at the minimum of average costs.

Figure II. Diagrammatic representation of excess capacity as a barrier to entry.



Point e is the limit price and capacity combination. Firms operating at K_1 charging P_1 are operating with excess capacity equal to $K_1 - K'$. The plant is sufficiently large to be efficient at K_1 but the firm operates at K' . The ability, if need be, to shift output to K_1 is a sufficiently credible threat to contain potential entrants. Underlying this threat is the assumption that when a threat is revealed, the incumbent can increase output to K_1 immediately and at non-prohibitive incremental costs. The theory assumes that incumbents have significant cost advantages over potential entrants and that a substantial if not majority of costs are fixed, i.e. must be covered regardless of the scale of operation. Why then doesn't the firm operate at the monopoly capacity-output level? The answer is that when faced with a fringe of potential entrants, the long-run monopoly price becomes insignificant, and decisions on price and output are made with respect to short-run cost conditions. However, if short-run marginal cost is constant, then it may be that the

monopoly price is the most profitable. Wenders' analysis fits liner shipping well.

Indeed, fixed costs do dominate the cost function, and to immediately increase output can be simply a matter of increasing the speeds of the vessels involved in a particular service. Brooks (2000) agrees, writing, "...a line may increase capacity on a particular route to act as a barrier to entry (or as a preemptive grasp for market share) or may invest in terminals, inland facilities or agency networks to achieve a similar outcome."⁶² A strategy of excess capacity, as opposed to one of predatory pricing, is also unlikely to jeopardize antitrust immunity among incumbent liners. The strategy of holding reserve capacity is even more feasible if the average cost curve is flat-bottomed because a flat-bottomed average total cost curve extends the range of excess capacity that can be held as an entry deterrent.

An implication of the work of Fox (1994) adds formal weight to the notion that incumbent liner shipping firms hold excess capacity. Under the assumption that a liner shipping conference is a cartel, Fox implies that excess capacity is the result of competition among cartel members in the provision of quality, which in liner shipping means faster, more frequent and more reliable services. Since prices are fixed by the cartel, the choice of quality is the most likely means available for individual members to increase their market share. The effect of this pursuit of quality may be excess capacity that incidentally forestalls entry.

The above works would have resonance among liner shipping firms since it is generally agreed that a by-product of over-investment in capacity is a major determinant

⁶² "Agency networks" refer to independent firms that act as sales agents for the carrier, or that provide freight forwarding services such as "stuffing" containers, then trucking or railing them to the ports of discharge for the ocean-bound leg of the journey.

of the weak profitability that has persisted in this industry over time. The application of these models to liner shipping or any other decreasing cost industry, would require separating and quantifying the entry-detering element in capacity investment from any investment that is driven by demand and/or other peculiarities of the industry itself. For example, in a decreasing cost industry with technical change, this could be an especially difficult distinction to make, since investments made under these conditions can appear to be an attempt to capture economies of scale rather than a means of precluding entrants.

The way in which firms choose capacity can provide insight into the state of the core, natural monopoly and the contestable markets hypothesis. Each market characterization is a potential source of excess capacity. In empty core markets, the inability to efficiently match supply and demand will produce excess capacity. Natural monopolies under conditions of uncertain demand exhibit excess capacity because of the need to keep reserve capacity on hand to cover periods of peak demand. In a decreasing cost industry the advantage should always go to the incumbent; however, if potential entrants are heavily subsidized, the subsidy can erase at least in part the incumbent's advantage. Moreover, in a decreasing cost industry (in both production and distribution), various authors have shown that social welfare is maximized only when just a few or even one firm operates. In markets that are otherwise contestable, an entry-detering strategy may involve keeping enough reserve capacity to reduce the prospects for an incumbent to gain a foothold in the market. The distinction between excess capacity that constitutes reserve capacity held to cover periods of high demand and that which is strategic entry-detering capacity is an integral part of this analysis.

Empirical Evidence of Strategic Excess Capacity

Empirical work in the study of excess capacity in oligopoly, particularly in industries with a high degree of capital mobility, is relatively rare. Most investigations into excess capacity as a strategic choice among incumbents are theoretical in nature and rely upon the tools of game theory to arrive at their conclusions. This is probably more to do with the difficulty in finding adequate data, than with a concurrence among economists about the results. What most of these studies seem to suggest is that strategic excess capacity is more likely an action of last resort than a variable of first choice. That is, for firms in industries that feature high natural barriers to entry, strategic excess capacity is a non-optimal pursuit.

In the 1970s and 1980s there were some studies of excess capacity that are worth reviewing, even though none have revealed overwhelming support for the theory of excess capacity as an entry deterrent. Masson and Shaanan (1986) estimated a three-equation recursive model of non-industry specific excess capacity in the U.S. economy for three sample periods. They attempted to separate excess capacity created by strategic decisions and that created by misjudging demand. They found only weak evidence to support the strategic excess capacity hypothesis. However, they did find stronger evidence that excess capacity compliments the ability of firms to follow a practice of limit pricing, and furthermore, that the more excess capacity carried by incumbents, the higher can be their limit price. Gilbert and Lieberman (1987) studied the investment behavior of firms in 24 chemical product market industries. Using a discrete choice probability model to predict when firms are likely to expand capacity, they found that the

entry-detering effects of preemptive investment are real but temporary. In order for the strategy to be truly effective it would have to be repeated over time. Lieberman's 1987 study of chemical processing plants found that firms in this industry kept excess capacity "to accommodate demand variability and capital lumpiness." Lieberman does concede, however, that there are instances where incumbents built strategic excess capacity once the threat of entry was revealed. Hilke (1984) adds excess capacity to a "traditional formulation" of entry that relies upon expected profits and industry growth as inducements to entry. He measures excess capacity at the top of the business cycle to avoid incidental excess capacity that could result from downturns in demand. Applying this specification to a cross section of industries revealed that while excess capacity was negatively associated with entry, its impact was not statistically significant at the 10% level. Esposito and Esposito (1974) studied how market structure may contribute to an understanding of excess capacity. They found that excess capacity is higher in "partial oligopolies", i.e. those industries with moderately high concentration, than in "tight oligopolies", i.e. industries that are very concentrated, or industries that are perfectly competitive. The authors surmised that partial oligopolies are less able to coordinate investment decisions in new capacity when demand turns up than tight oligopolies, because the latter market structure consists of fewer firms, which facilitates the coordination of investment activity. Excess capacity in industries that are perfectly competitive industries was negligible. More recently, Driver (2000) estimated a pooled time series model of capacity utilization for a sample of British firms in several manufacturing industries. There was evidence of strategic excess capacity in three out of 12 industries. These three industries shared features such as low product differentiation,

high rates of growth and perhaps most importantly, high levels of industrial concentration as measured by the Herfindahl index. In the remaining nine industries, excess capacity was more likely to be precautionary, in part, Driver suggests, because entry barriers formed by product differentiation were higher.

XI. A Model of Strategic Reserve Capacity

Drawing from the ideas of Gaskins, Spence and Wenders, the model presented in this dissertation attempts to incorporate the effect of the propensity of rival firms to enter an incumbent's market on the incumbent's choice of capacity. Elemental in Gaskins' model is the assumption that incumbent firms maximize long-run profits rather than short-term profits. This assumption permits the incumbents to follow a dynamic limit price strategy in order to thwart potential entrants. The limit price is defined as that price for which net entry is zero. In general, a limit price is sufficiently high to permit positive profits, but sufficiently low that an entrant would be unable to recover his fixed costs of entry. Applying a limit price model to liner shipping markets, however, would be problematic. Although there has been some degree of simplification over time, pricing decisions in liner shipping markets rely on an extremely complex system of rates that vary by commodity, by route, and by weight. With such a varied and lengthy commodity list, the question becomes which commodity-route pair should the limit pricing strategy be applied to, and for how long? Conceptually, liner carriers could simply apply a standard discount to each commodity-route pair. However, since the ability to price discriminate essentially makes the liner carrier a multi-product firm, an across the board

limit price could easily create unnecessary losses in producer surplus. Moreover, liner carriers may run fleets composed of ships with heterogeneous cost functions, which could also be a major source of inefficiency. Additional constraints arise because carriers may impose surcharges on particular trade routes at irregular intervals to cover the costs of repositioning equipment during periods of steep trade imbalances, or for unanticipated spikes in the costs of fuel or fees paid to ports. Cost functions may also differ significantly across heterogeneous incumbent firms. A price that is above average cost price for one member of the conference may not cover another's average costs. Getting liner conference members to agree on a limit price under these conditions would require in-depth knowledge of member costs at the plant (ship) level. An agreement on a limit price would also imply equal profit discounting among conference members. Differences in costs and discounting would create additional hurdles in getting conference members to agree on a limit price strategy. Finally, there may also be differences in perception among conference members regarding the threat of entry.

Another difficulty in applying the limit price model to the liner shipping industry is that even though carriers may themselves receive direct or indirect subsidies, incumbent firms may face entry from an even more heavily subsidized or protected entrant. In the pursuit of both economic and geopolitical objectives, national governments have shown themselves quite willing to provide subsidies either in the form of direct cash payments, low interest loans to domestic shipyards, or indirectly through the formulation of policies that reserve certain cargo for domestic carriers. A limit price, in the case of a determined entrant under subsidy from its own government, would be easily overcome.

Subsidies are generally agreed to be largely responsible for the rapid growth in the shipping industries of several less-developed countries.

On a more practical empirical level, freight rates are difficult to obtain except in an aggregate form. And even if freight rates were readily available, it would be just as difficult for the researcher to decide which commodities the limit price hypothetically applies to as it would be for the conference members themselves.

A means of circumventing the problem of modeling conference freight rates is to realize that a limit price strategy is the reduced form of a reserve capacity strategy, and that the latter may in fact be preferred because of its ease of implementation. There is a negative relationship between average freight rates and excess capacity.⁶³ Therefore, it is reasonable to state that excess capacity among conference or alliance members may in fact be a limit price strategy in disguise. Certainly, choosing a single capacity level that would deter entry is easier than choosing a limit price strategy by commodity-route pair. Capacity is also easier to monitor both among conference members and among potential entrants. In addition, a strategy of reserve capacity would be less likely to receive the scrutiny of regulatory authorities, since these regimes are charged mainly with scrutinizing liner pricing and not the investment decisions of conference members.

Assuming that excess capacity is a valid strategy, a model of the choice of capacity under conditions of hit and run entry is outlined below. The model assumes, as in Gaskins, that liner shipping is an oligopolistic industry with a fringe of well-behaved potential entrants. Well-behaved in this context means that the incumbent oligopolists are

⁶³ Based on a recent analysis by PIERS/Journal of Commerce. In general, freight rates follow excess capacity with a 2-4 quarter lag on the major U.S. east-west trade routes.

able to predict entrant behavior based upon a known set of parameters. In practical terms, the fringe of a liner market would be independent operators and tramp or charter vessels that enter markets opportunistically. The model is necessarily dynamic since to be effective, the holding of reserve, entry-detering capacity must be repeated an infinite number of times. The following model adopts the above assumptions and adds explicitly that the industry is subject to hit and run entry. Hence, sunk costs are assumed to be zero.⁶⁴ Of primary importance in this model is the distinction between productive capacity and reserve capacity. Depending upon the state of demand, productive capacity can become reserve capacity and vice versa. The two are assumed to be fungible, and although they are assumed to be perfect substitutes, they may not always be. This is discussed in further detail below.

The Model

There are two players in the market; incumbents and fringe. They compete in a Bertrand-like fashion in which each believes that his actions can affect the behavior of his rival. There are no sunk costs. It is assumed that incumbent firms maximize long-term profits, which requires them to maximize capacity utilization on every voyage. Excess capacity is the only means by which an incumbent can forestall entry/expansion of rival fringe firms. This excludes the influence of product differentiation, which as was mentioned in chapter VI, may offer incumbents protection from fringe firm encroachment. An example will serve to illustrate. Suppose there is a fixed level of

⁶⁴ This of course implies that the liner shipping market is structurally contestable.

demand, Q . And suppose for a given speed and size of the incumbent's ship, the incumbent can only satisfy $\frac{F}{2}$ of this demand on one voyage, so it must make two voyages. Under these circumstances, the incumbent is vulnerable to a potential entrant during the first voyage. To defend against the potential entrant, the incumbent is required to either deploy an additional a vessel in the service, increase the speed of the existing service, or replace the vessel with one that can accommodate all of the cargo on one voyage. In each case, the frequency of service rises because more cargo can be transported in less time. The assumption is that incumbents will increase the frequency of their service when there is a threat of entry or expansion from fringe competitors.

Output is assumed to be a function of aggregate capacity employing a Cobb-Douglas technology. At this point it is necessary to define liner shipping output. Output may be thought of in two ways; first, as the total volume of cargo transported per unit of time, and second, as the frequency of service offered to importers and exporters. Transport is a derived demand. Carriers obviously do not produce the cargo, but instead produce the service by which the cargo is transported over water. In other words, their output can be measured as the volume of cargo that can be potentially transported per unit time. This service is produced more or less, to match the level of demand, but since it is a fixed-schedule service, it does not always do so. Liner shipping output is thus best considered as the frequency of service offered by the carrier rather than the amount of cargo transported, even though the two will be closely related.

Returning to the model,

$$1) F(t) = K(t)^\alpha$$

Where $F(t)$ is incumbent output (service frequency) at time (t) , $K(t)$ is capacity and α is the returns to scale parameter. Capacity is a combination of the size of the ship and its speed. Incumbent aggregate capacity is made up of productive capacity $K_p(t)$ plus excess reserve capacity, $K_r(t)$ that is employed when entry is threatened. Hence aggregate capacity is

$K(t) = K_p(t) + K_r(t)$. The production function is thus,

$$2) F(t) = [K_p(t) + K_r(t)]^\alpha$$

and, the change in incumbent service frequency over time is given by,

$$3) \frac{dF(t)}{dt} = F(t)^\beta - sK(t) + \frac{dX(t)}{dt}$$

where $F(t)$ is market demand (measured in terms of frequency of service) β is the elasticity of demand, $K(t)$ is incumbent capacity in period (t) , and $\frac{dX(t)}{dt}$ is the rate of change of fringe firm capacity in period (t) . The coefficient s on $K(t)$ is the vessel scrapping parameter, which may alternately be thought of as a rate of depreciation. Scrapping is simply the disassembly of a vessel into its component parts for use as

scrap.⁶⁵ Incumbents observe $\frac{dX(t)}{dt}$ and decide whether to add or reduce their frequency of service in a given trade lane. Capacity is assumed to be perfectly mobile. Hence when $\frac{dX(t)}{dt} > 0$, incumbents instantaneously increase their frequency of service to prevent further erosion of market share. The addition can be drawn from a separate market, or lie within existing capacity by running the vessel at higher speeds. When $\frac{dX(t)}{dt} < 0$, holding all else constant, incumbents may reduce their frequency of service. Assuming that the market clears (frequency of service supply=frequency of service demand), we can substitute for $F(t)$:

$$4) \frac{dF(t)}{dt} = [K_p(t) + K_r(t)]^{\alpha\beta} - sK(t) + \frac{dX(t)}{dt}$$

The change in entrant capacity in the incumbent's market at time t is given by:

$$5) \frac{dX(t)}{dt} = k[F(t)^\beta - K(t)] - X(t)$$

$F(t)^\beta$ is market demand so $F(t)^\beta - K(t)$ is excess demand. When $F(t)^\beta > K(t)$, excess demand is positive and $\frac{dX(t)}{dt} > 0$ by a factor of k , the propensity of fringe firms to

⁶⁵ Scrapping or ship breaking is a large industry in India, Pakistan, China and elsewhere in the developing world. Ocean-going vessels are disassembled in an extremely labor-intensive (and dangerous) process into their component parts. The metals are often melted down and reforged as farming/garden tools and the engines are used to power small factories.

enter/expand in the incumbent's market, all else equal. The parameter k lies between 0 and 1. It is assumed that only incumbents scrap vessels.

Since $K(t)$ is aggregate capacity, we can substitute $K_p(t) + K_r(t) = K(t)$

$$6) \frac{dX(t)}{dt} = k[F(t)^\beta - K_p(t) - K_r(t)] - X(t)$$

Substitute $\frac{dX(t)}{dt}$ (6) to (3) .

$$7) \frac{dF(t)}{dt} = [K_p(t) + K_r(t)]^{\alpha\beta} - sK(t) + k[F(t)^\beta - K_p(t) - K_r(t)] - X(t)$$

To maintain a constant level of service frequency over time, incumbents set $\frac{dF(t)}{dt} = 0$.

$$8) 0 = [K_p(t) + K_r(t)]^{\alpha\beta} - sK(t) + k[F(t)^\beta - K_p(t) - K_r(t)] - X(t)$$

To solve for $K_r(t)$, it is easiest to assume linear demand and constant returns to scale so that $\alpha\beta=1$. In addition, for all practical purposes, scrapping is zero. Container ships are long-lived assets that are rarely scrapped. Instead, older vessels are more likely to end up either on the charter market or redeployed to some other less profitable trade lane.

$$9) 0 = K_p(t) + K_r(t) + kF(t) - kK_p(t) - kK_r(t) - X(t)$$

Solving for $K_r(t)$:

$$10) K_r(t) = \frac{1}{1-k} X(t) - K_p - \frac{k}{1-k} F(t)$$

$K_r(t)$ is reserve or excess capacity evaluated at a constant level of service frequency given potential entry. Taking derivatives of $K_r(t)$ with respect to $X(t)$ yields the key analytical result, or what shall be called the preemption effect.

$$11) \frac{\partial K(t)}{\partial X(t)} = \frac{1}{1-k} > 0$$

The higher is k , the higher is the tendency of incumbents to add excess capacity. The derivative implies that incumbents observe fringe firm behavior in period (t) and decide how much reserve capacity to add in period (t) based on k . When fringe firms enter in period (t) , incumbents add capacity at the rate of $\frac{1}{1-k}$. The larger is k , the higher the propensity of fringe firms to enter and the higher will be levels of incumbent excess capacity. In the limit, $\lim_{k \rightarrow 1} \frac{1}{1-k} \rightarrow \infty$, incumbents would have to add an infinite amount of capacity to forestall entry.

Local Dynamic Stability

It has been stated more than once in this dissertation that entry can be a destabilizing force in liner shipping markets. The instability is in the form of volatile

freight rates. The most basic and strongest assumption in the following analysis is that freight rates are determined almost entirely by available supply ($K(t)$ and $X(t)$) and demand. The analysis discounts the impact on pricing of the value of freight. The question is whether the system is stable, that is, given the presence of opportunistic fringe firms, does incumbent maintenance of strategic reserve capacity enhance the stability of the system or does it further destabilize the system. First, consider the stability of the system with no reserve capacity.

A slight modification of the above model can be used to determine the effect of incumbent behavior on fringe firm propensity to enter. If demand is held constant, when fringe firms add capacity, incumbent capacity falls. The model then becomes:

$$(12) \frac{dK(t)}{dt} = F(t)^\beta - sK(t) - hX(t)^\sigma \text{ is the rate of change of incumbent capacity, and}$$

$$(13) \frac{dX(t)}{dt} = k[F(t)^\beta - K(t)] + hX(t)^\sigma \text{ is the rate of change of fringe firm capacity,}$$

with the slight modification of adding a term for the fringe firm level of technology (h) and returns to scale (σ). The equations for the rate of change for both incumbent and fringe firm capacity are written in continuous time. Incumbents retain the Cobb-Douglas technology but do not carry strategic reserve capacity. Assuming the supply of service frequency is a function of capacity, equation (12) then becomes

$$(14) \frac{dK(t)}{dt} = g[K(t)^\alpha]^\beta - sK(t) - hX(t)^\sigma$$

and (13) becomes

$$(15) \frac{dX(t)}{dt} = k[gK(t)^{\alpha\beta} - K(t)] + hX(t)^{\sigma}$$

It is assumed that only incumbents own and scrap vessels while potential entrants rely upon the second-hand and leasing markets for used ships. It is easiest to assume demand is linear and constant returns to scale. Hence $\alpha=\sigma=\beta=1$.

$$(16) \frac{dK(t)}{dt} = g[K(t)] - sK(t) - hX(t)$$

and (13) becomes;

$$(17) \frac{dX(t)}{dt} = k[gK(t) - K(t)] + hX(t)$$

Setting the derivatives equal to zero allow for a solution for incumbent and fringe firm capacities, the solution for $K(t)$ is;

$$(18) K(t) = \left[\frac{2hX(t)}{k(1-g) - s + g} \right]$$

As k rise, $K(t)$ declines, all else equal since entry reduces incumbent market share.

The solution for fringe firm capacity is more complex;

$$(18) X(t) = \frac{sK(t)}{h} \left[\frac{(g + k(1 - g) - s)}{(g - k(1 - g) + s)} \right]$$

Like incumbents, the magnitude of k , s , and the technical parameters determines the level of fringe firm capacity. It is more instructive to test the stability of the system. First take a Taylor expansion to form a linear approximation to equations (16) and (17) and write the system as:

$$(19) F(K, X) = gK(t)^a - sK(t) = +hX(t)^\sigma$$

$$(20) F(K, X) = kgK(t)^a - kK(t) = -hX(t)^\sigma$$

$$(21) (\alpha gK(t)^{\alpha-1} - s)(K(t) - K(t)_0) - \sigma hX(t)^{\sigma-1}(X(t) - X(t)_0) = 0;$$

$$(22) (\alpha gkK(t)^{\alpha-1} - k)(K(t) - K(t)_0) + \sigma hX(t)^{\sigma-1}(X(t) - X(t)_0) = 0;$$

The Jacobian of the above system is written:

$$(23) J = \begin{bmatrix} \alpha gK(t)^{\alpha-1} - s & -\sigma hX(t)^{\sigma-1} \\ \alpha gkK(t)^{\alpha-1} - k & \sigma hX(t)^{\sigma-1} \end{bmatrix} \begin{bmatrix} K(t) - K(t)_0 \\ X(t) - X(t)_0 \end{bmatrix}$$

Under the assumption of constant returns to scale on the part of incumbents and entrants, we have the following 2 X 2 Jacobian matrix;

$$(24) J = \begin{bmatrix} g - s & -h \\ k(g - 1) & h \end{bmatrix} \begin{bmatrix} K(t) - K(t)_0 \\ X(t) - X(t)_0 \end{bmatrix}$$

Stability requires that the trace of the above Jacobian (J) be negative and the determinant positive. The trace of the matrix is $(g-s) + h$ and the determinant is $h(g-s)+h[k(g-1)]$.

The characteristic equation is then $\lambda^2 - (h+g-s)\lambda + h(g-s)+h[k(g-1)]$

To simplify further, suppose scrapping is zero. The characteristic equation becomes

$$\lambda^2 - (h+g)\lambda + h(g(1+k)-k)$$

It remains to consider the signs on the eigenvalues or the roots of the characteristics equation. For local stability, both eigenvalues should be negative. The characteristic roots can be expressed as,

$$\lambda_1, \lambda_2 = \frac{(trJ \pm [(trJ)^2 - 4Det(J)]^{1/2})}{2}$$

The eigenvalues are;

$$(25) \lambda_1 = \frac{((h+g) + [h+g^2 - 4(h(g(1+k)-k)]^{1/2})}{2} \text{ and}$$

$$(26) \lambda_2 = \frac{((h+g) - [h+g^2 - 4(h(g(1+k)-k)]^{1/2})}{2}$$

The local stability of the system depends entirely on the magnitudes of h , g and k .

Chiang provides three cases for which the local stability of the system can be

determined.⁶⁶ In each case, stability is achieved if $Det(J) > 0$ and that for $trJ < 0$. By

⁶⁶ Case 1, $(trJ)^2 > 4(Det(J))$. Case 2, $(trJ)^2 = 4(Det(J))$. Case 3, $(trJ)^2 < 4(Det(J))$. In any case, the equilibrium is either unstable or a vortex because in our system, $trJ = (h+g)$. If we allow scrapping, we get $trJ = (h+g) - s$ and there is a chance that the system can achieve stability.

assumption, $h, g > 0$ so there can not be a stable equilibrium in this system because the trace of the Jacobian will always be positive. Only if we reverse the assumption that scrapping is zero and let s be greater than $g+h$ is it possible for the system to achieve a stable equilibrium. This makes good intuitive sense, since with no scrapping, capacity simply accumulates forever. But we know that ship owners have traditionally shown great reluctance to scrap their vessels. Hence, with constant returns to scale and linear demand, the system is likely to be unstable. A host of alternative stability conditions can be gleaned from the Jacobian matrix. The common thread woven among them is the role of k, h, g and s .

Now consider the system when incumbents keep excess capacity to deter entrants. We want to see if reserve capacity, through its impact on entry, has a stabilizing or destabilizing effect on the equilibrium of the system. In this case, incumbent total capacity rises when fringe firms threaten because we allow them to add to hold excess capacity in order to deter further encroachment. Hence the sign of $X(t)$ changes to positive from negative. Again, from equations (1) and (2) above we have with a slight modification to allow for reserve capacity,

$$(27) \quad \frac{dK(t)}{dt} = g[K(t)^{\alpha}]^{\beta} + K_r(t) - sK(t) + hX(t)^{\sigma}$$

$$(28) \quad \frac{dX(t)}{dt} = k[F(t)^{\beta} - K(t)] + hX(t)^{\sigma}$$

In order to arrive at a 2X2 matrix, we have to make an assumption about $K_r(t)$. We know that reserve capacity is potentially fungible, that is, it may exist within productive

capacity as extra speed and service frequency. It may also exist as separate vessels, perhaps with older technology. Under this assumption, there is a technical parameter associated with it. Let m be this parameter. Then (1) becomes,

$$(29) \frac{dK(t)}{dt} = g[K(t)^a]^\beta + mK_r(t) - sK(t) + hX(t)^\sigma$$

Proceeding as before, the Jacobian becomes

$$(30) J = \begin{bmatrix} \alpha g K(t)^{a-1} - s + m & \sigma h X(t)^{\sigma-1} \\ \alpha g k K(t)^{a-1} - k + m & \sigma h X(t)^{\sigma-1} \end{bmatrix} \begin{bmatrix} K(t) - K(t)_0 \\ X(t) - X(t)_0 \end{bmatrix}$$

And under the assumption of linear demand and constant returns to scale,

$$(31) J = \begin{bmatrix} g - s + m & h \\ k(g - 1) + m & h \end{bmatrix} \begin{bmatrix} K(t) - K(t)_0 \\ X(t) - X(t)_0 \end{bmatrix}$$

Again, Chiang's classification demands that the equilibrium can achieve stability if $tr(J) < 0$ and $Det(J) > 0$. The addition of reserve capacity to the system then introduces m , which raises the level at which s must rise to achieve $tr(J) > 0$. The $Det(J)$ is now $h(g-s+m) - h[k(g-1) + m]$. The addition of m in the determinant just cancels out. Given that m raises the likelihood that the trace is positive, the addition of excess capacity to the system decreases the stability of the system. However, the argument assumes that reserve capacity has no effect on k . If reserve capacity can indeed reduce k then it may have a stabilizing effect. Suppose, after reserve capacity is introduced, k falls to zero. Then the

$Det(J)$ will be k is $h(g-s)$. As long as $g > s$ then $Det(J) > 0$ and the likelihood of achieving stability rises.

XII. A Model of Technical Change in Liner Shipping

As discussed earlier, there are two separate markets in ocean shipping - bulk and liners. In bulk shipping, markets are competitive and as such, the choice of technology exhibits starkly different characteristics from liner shipping. Bulk shipping technology will more likely reflect demand conditions rather than strategic interactions among incumbents and potential entrants. The difference can be illustrated in a simple optimization model attributed to Beenstock and Vergottis (1993). In their model, a number of simplifying assumptions is made. First, there is no cost of waiting time at ports. Ships are able to load and unload their cargoes instantaneously. Carrying capacity of ships is fixed and does not vary with environmental conditions such as the weather. The only means by which a ship manager can increase capacity is to increase the speed of the vessel. It is assumed that speed can vary from zero to infinity, and that there are decreasing returns to speed. Output is then proportional to the speed of the vessel. Cost is a function of labor and capital. Labor costs are assumed to be fixed. This can be justified by the fact that maritime rules govern crew requirements in terms of number and skill for a given vessel. Moreover, since the size of the vessel cannot be altered, capital is also fixed so that $\frac{L}{K}$ is constant. Hence the only choice variable for the ship manager's profit function is how fast to run the vessel. The ship manager's objective is to maximize

profits. Engineering studies have shown that the relationship between the amount of bunker fuel consumed on a voyage and the speed/output of a vessel can be given by:

- 1) $B = \sigma^a$; where B is bunker fuel consumption, σ is the speed of the vessel and a is the technical parameter. Decreasing returns to speed imply that $a > 1$.

Since speed is directly related to output, for a given ship, σ may also be the output of the vessel in terms of freight carried per unit time.

The ship manager's profit function is given by:

- 2) $\Pi = F\sigma - P_b B - C$; where F is the freight rate, P_b is the price of bunker fuel and C is the fixed costs including labor of the vessel.

Substituting (1) into (2) yields;

$$3) \Pi = F\sigma - P_b \sigma^a - C$$

The first order condition is;

$$4) \frac{\partial \Pi}{\partial \sigma} = a \sigma^{a-1} = 0;$$

solving for optimal σ yields:

$$5) \left(\frac{F}{a} \right)^{1/(a-1)}$$

The relationship expressed in equation (5) implies that as F rises, it pays to increase the speed and consequently the output, of the vessel. When F falls, the opposite relationship holds. A smaller value of the parameter a , implies a more cost efficient technology and hence a flatter production function. As a rises, it pays to reduce output since costs are rising disproportionately. The fundamental element that distinguishes this model from a liner service model is in the choice of speed. In bulk market, the ship manager has this flexibility. When a demand shock causes freight rates to fall, the bulk ship manager can reduce his speed and hence his operating costs to sustain profits. The liner carrier has no such flexibility in the short-run. When freight rates fall, the scheduled service must still be observed. The committed nature of the service increases the importance of employing the most cost efficient technology. An added dimension to technology choice in liner shipping is the entry deterrence component. Rival entry affects incumbent profits if in the post-entry game, the incumbent chooses not to accommodate the entrant, or the entrant decides to play an aggressive Bertrand game. Even if entry does not occur, however, potential aggressive entrants and their technology must be accounted for in the incumbent's profit function. Beenstock and Vergottis' model can then be altered in the following way. Again, there are two market sectors, incumbents and fringe firms. There is no product differentiation and competition is Bertrand. Fixed costs are assumed to be equal in both sectors. Aggregate industry profits are given by;

$$6) \quad \Pi = \sum_{i=1}^2 \Pi_i$$

where i indexes the sector.

The share of industry profits held by incumbents is s , and that of fringe firms is $(1-s)$.

$$7) \quad \Pi = s\Pi_I + (1-s)\Pi_E$$

As in bulk shipping, the profit function for sector i is given by;

$$8) \quad \Pi_i = F\sigma_i - P_b\sigma_i^a - C$$

then total industry profits are given by;

$$9) \quad \Pi_i = s(F\sigma_I - P_b\sigma_I^a - C) + (1-s)(F\sigma_E - P_b\sigma_E^b - C)$$

a indicates the state of technology in the incumbent sector and b the technology in the fringe firm sector. Again, it is assumed that there are decreasing returns to vessel speed so $a, b > 1$.

Maximizing industry profits with respect to σ_i gives rise to the first order conditions,

$$10) \quad \frac{\partial \Pi}{\partial \sigma_I} = sF - saP_b\sigma_I^{a-1} = 0;$$

$$11) \quad \frac{\partial \Pi}{\partial \sigma_E} = (1-s)F - b(1-s)P_b\sigma_E^{b-1} = 0;$$

By eliminating s , $1-s$ and P_b ,

$$12) 1 = aP_b\sigma_I^{a-1};$$

$$13) 1 = bP_b\sigma_E^{b-1};$$

Solving;

$$14) \sigma_I = \left[\frac{b}{a\sigma_E^{b-1}} \right]^{1/a-1}$$

Equation (14) implies that when b rises relative to a , incumbent technology is superior and optimal output of incumbents rises. If fringe firms enter with better technology then $b < a$ and optimal output of incumbents falls. In order to maintain output at pre-entry levels, incumbents must choose a better level of technology.

By the chain rule;

$$15) \frac{\partial \sigma_I}{\partial \sigma_E} = \frac{1}{a-1} \left[\frac{(b-1)b}{a\sigma_E^{b-2}} \right] \left[\frac{b}{a\sigma_E^{b-1}} \right]^{\frac{1}{a-1}-1} > 0 \text{ since } a, b > 1 \text{ by assumption.}$$

This derivative suggests that the more fringe firms enter, the higher is incumbent output in this zero sum game. From here it is not difficult to imagine over-investment and hence excess capacity, particularly if demand is growing more

slowly. The elements of the model suggest a technology race where the sector with the most cost efficient technology at any point in time gains market share at the expense of the rival firm.

XIII. Econometric Model Specification

Having exposed the theoretical constructs, the objective of the econometric model is to differentiate strategic excess capacity among incumbents (liner conference members) from excess capacity that may occur as a result of the alternative sources identified thus far:

- 1) Natural monopoly, in which excess capacity results from the dynamic capacity expansion problem and volatile demand.
- 2) The empty core model of Telser, in which divisibility of demand and indivisibility of supply are likely to create persistent period of excess capacity, particularly when capital is a long-lived asset and when conditions for entry are not prohibitive. The model does not explicitly address the issue of contestable markets in liner shipping, but it may be inferred that if incumbents maintain a stock of excess capacity as a barrier to entry, then structural barriers to entry are more likely to be low.
- 3) Technical change, which if progressing more rapidly than demand, can cause prolonged periods of excess capacity.
- 4) Other sources such as macroeconomic conditions that drive shipping market cycles and government intervention in shipping markets.

An attempt will be made to specify a model that can account for each of these concepts and estimate them simultaneously. The model does not explicitly address whether liner shipping markets are contestable. However, it was necessary earlier in this dissertation to make the case that even if structural barriers to entry are low, incumbents may pursue a strategy of erecting artificial barriers to entry, including the maintenance of a stock of excess capacity.

With respect to an indicator of strategic excess capacity, the first problem is to identify a variable that incumbents' choice of capacity reacts to outside of normal supply and demand conditions. The most obvious indicator is what has been termed fringe firm capacity entry and/or expansion. Controlling for all other factors involved in capacity choice among incumbents, an expansion of fringe firms should motivate incumbents to expand their own capacity as a defense against fringe firm encroachment.

The effects of other factors, such as natural monopoly, the theory of the core, and technical change may be approximated in the following manner. If liner shipping tends to natural monopoly then, as in the case of public utilities, carriers must observe past demand volatility in order to decide how much capacity will be needed to cover spike periods, even if that capacity is idle during off-peak periods. Hence a positive and significant relationship between demand volatility and excess capacity increases the likelihood (per Sharkey) that economies of scale exist, and subsequently offers limited support for the notion that liner shipping tends toward natural monopoly.⁶⁷ The effects of an empty core may be revealed if additions to capacity necessarily, through the lumpiness

⁶⁷ See Sharkey's third source of economies of scale, page 34 of this dissertation.

of that capacity bring about excess capacity. This implies that the higher is the level of capacity deployed to meet demand, the higher will be excess capacity, because as has been made clear earlier, in an empty core market, there is a low probability that supply meets demand exactly at any point in time. On the other hand, measures to restrict competition may have a dampening effect on excess capacity. This can be captured by quantifying the extent of cooperation in the market among incumbents by means of a concentration measure. Technical change may contribute substantially to excess capacity, since a race between incumbents and potential entrants to deploy the most cost-efficient vessels may develop in a dynamic setting. The first player to deploy the technology gains market share, but may contribute to excess capacity. Finally, other macroeconomic sources of excess capacity will be incorporated into the model to complete the picture. This can most closely be approximated by total demand, which in liner shipping is closely and positively correlated with income.

Variables and Anticipated Signs

The econometric model is roughly $K = F(X)$, where K is excess capacity and X is a vector of variables that capture the effects of the sources of excess capacity identified above. The effect of the degree of contestability of the liner shipping market is left out since it is an issue of causality. The results of the model will permit inferences to be made about the contestability of liner shipping markets.

Excess Capacity - Excess capacity of conference carriers is the dependent variable. For trade route i , excess capacity is measured by the difference between the number of TEUs lifted and the number of TEUs deployed. The nominal rated capacity plus other statistics of all registered container carrying vessels, are listed in the *Lloyds Register of Ships* and in *Containerization International Yearbook*. Typically, the ratings are based upon the volume of containers that can be carried aboard with no attention given to weight. But a vessel may actually “weigh out,” or exceed its safe weight limit, before it “cubes out,” or exceeds the limit on the number of available container slots. The exact capacity in TEUs thus depends on the commodity carried. If commodities are heavy cargoes such as lumber, waste paper, hay, or metal scrap, the nominal capacity should be adjusted downward. On the other hand, if the goods being loaded are high-value but lightweight consumer goods, then the nominal capacity is equal to the real capacity. Hence, the real levels of capacity on a particular trade route depend in part on the commodities being exchanged. Since U.S. containerized exports are typically lower-value and heavy commodities, any measurement of capacity utilization would be biased downward unless appropriate adjustments are made. On containerized imports, the U.S. takes in predominantly manufactured consumer goods, which are relatively light. Therefore, the nominal rated capacity requires no adjustment. To come to an exact measure based on weight and volume is beyond the scope of this paper. In practice, liner carriers generally apply a weigh out factor of between 3-5% of nominal rated capacity on export lanes and 0% on import lanes.

Another issue that arises when calculating capacity is that of transshipments. On vessels serving more than one trade lane on a voyage, there may be cargo aboard its first

port of call that is shipped to its second port of call, not necessarily the final destination. For example, on U.S. exports a vessel leaving the U.S. west coast for Asia may unload X TEUs in Singapore but then load $X+Y$ TEUs to be transshipped to Hong Kong. To ensure that there is room on the vessel for Y TEUs, it may have left some space vacant when it left the U.S. west coast. The same is true on imports. This could bias downwards the measure of capacity utilization. There is no data available on the volume of these transshipments by vessel and as a result, a broad assumption about vessel operations must be made. It is reasonable to assume that a ship will consistently be at least 60% full when it leaves or arrives at a U.S. port. If it consistently is not, and the route is one in which transshipments are important, then it can be assumed that the empty space is for transshipments. In this case, rather than apply the nominal rated capacity as the base for calculation, it is better to find an historical level of TEUs carried and use that as the base. This method can also cover the weigh out - cube out problem since the reason a vessel is less than 60% full may be due entirely to the weight of the cargo.

Concentration - after the 1984 Shipping Act, liner conferences were more loosely organized cooperative agreements with members free to pursue independent actions without reprisal. Entry into and exit from the conference was guaranteed, so that the number of firms involved became fluid over time. Therefore, the intensity of cooperative behavior among conference members is fluid over time, and it is unreasonable to treat the conference as a single firm. Instead, concentration within the conference is measured as the sum of the market shares of the four largest firms in a particular market at a particular time. The implications of concentration for excess capacity are that as concentration

rises, the conference is better able to coordinate the strategic decisions, such as the holding of excess capacity among its members, and will better maintain its market share *vis a vis* fringe firms. Thus, excess capacity is indeed a strategic tool to forestall entry, the relationship of concentration to excess capacity is anticipated to be positive.

Demand - demand is the total volume of trade per trade region, per direction of trade, measured in TEUs. It is available through the PIERS database, which covers origin-destination of U.S trade by volume to the level of the domestic shipper and foreign port. The higher demand is, the lower excess capacity will be.

Demand Volatility - if demand fluctuates widely, carriers will likely keep excess capacity on hand to cover spikes. Volatility is measured as the four-quarter maximum deviation (quarter-to-quarter) in demand growth from its long-term trend. Long-term growth is calculated as the coefficient in a regression of the log of demand on a constant and a time trend. The higher demand volatility is, the higher excess capacity will be. If the relationship is strong, it provides evidence, albeit limited evidence, of natural monopoly.

Entry and Conjectural Variations- entry, in this dissertation, primarily implies capacity expansion of fringe firms. Fringe firms are judged to be those not involved in liner conferences, although they may be involved in non-binding discussion agreements or even strategic alliances. If it can be determined that capacity expansion by fringe firms

causes additions to excess capacity on the part of incumbents, then it is evidence, all else equal, that excess capacity may serve as a strategic deterrent to potential entrants.

The Core - the effects of core emptiness must be approximated. In empty core markets, capacity increments are “lumpy,” or indivisible. Therefore, controlling for the level of cooperation among incumbent lines, if additions to productive capacity have a positive and significant effect on excess capacity, then that may be taken as support for the empty core hypothesis. However, in a market lacking a competitive empty, it pays for agents to cooperate in order to efficiently match demand with supply. In the liner industry this is accomplished by vessel-sharing partnerships and alliances. The more carriers cooperate, the less empty should be the core of the market. Therefore, the level of cooperation among carriers can measure the effect of the core. The PIERS data includes the vessel and each ship line carrying cargo aboard that vessel during a particular voyage. The more ship lines carrying cargo aboard the vessel, the higher is the number of voyages and the more cooperative the industry is becoming. As cooperation increases, excess capacity should decline. Unfortunately, the voyage count is likely to be collinear with incumbent capacity. To circumvent this is to assume that cooperation increases as the incumbent carriers’ share of demand rises. This is easily calculated as the market share of the conference and is anticipated to negatively affect excess capacity in two ways. First, under the assumption that the liner conference is a cooperative agreement, it is reasonable to state that increases in its share of the market may arise from sharing of equipment, including vessel space. This will have a negative impact on excess capacity. Further, if the conference share is high, fringe firms and new entrants may find it advantageous to

join the conference rather than enter or remain an independent operator. This provides a disincentive to keep strategic excess capacity.

Technical Change - technical change is often modeled using a simple time trend. In part, this is an artifact of the difficulty in quantifying technical change. A time trend is reasonable because both “learning by doing” and major technological advances are time sensitive processes.

Shipping Cycles - shipping markets, which include the wet-bulk, dry-bulk, heavy lift and general cargo (containerized) markets, tend to move in cycles. This suggests that capacity choice may be governed in part by expectations formed by the economic cycle.

Typically, world income rises then international trade increases. Ship owners invest in new vessels while reducing their scrapping activity of older less efficient vessels. The time lag between ordering and deploying a ship can lead to over-capacity when demand turns down. Ship owners “overshoot” because their expectations of increasing demand are not met, but the orders may already have been placed and well on their way to completion. The economic cycle then must be incorporated into a model of excess capacity. The growth rate of GDP in the U.S. and in U.S. trading partner countries can be used to proxy for economic cycles, however, GDP’s high correlation with container trade volume will create problems of multicollinearity. Since demand is closely related to income, the volume of trade can approximate shipping cycles.

Prices - high prices for new vessels should reduce fringe firm expansion plans, and thus reduce the need for incumbents to carry excess capacity. New build prices in U.S. dollars for various vessel sizes were obtained from Drewry Shipping consultants and deflated using the 1996 GDP deflator. It was decided to use prices for the largest vessel class since it is these ships that most contribute to excess capacity.

Policy - the effect of the Ocean Shipping Reform Act is modeled as a simple binary variable, taking on the value of 1 at the time of enactment and for all subsequent time periods and zero for all time periods before enactment.

Government Intervention - Subsidies may play a large role in the creation of industry level excess capacity. Subsidies to fringe firms create over-building in that segment, and, if entry deterrence requires excess capacity, among incumbents as well. Unfortunately there is no data that I am aware of that quantifies subsidy programs on a global basis. Previous studies have used dummy variables to indicate which trade lanes are likely to be affected.⁶⁸ But this is impractical as well, since the data set includes just over nine years by quarter. The researcher would thus have to determine which countries were active in providing subsidies at particular times during the sample period. Instead, since the data is a pooled cross section, information on subsidies may be embedded in the fixed effects, that is, in each trade lane's individual constant term. In trade lanes where governments actively promote their maritime industries, the effect on excess capacity should be

⁶⁸ See White (1988).

positive and greater than in regions with less active or no government assistance programs.

Empirical Specification

The econometric model is designed to incorporate the major sources of excess capacity identified in this paper and to quantify their effects. Data will be pooled across trade lane and direction. The first task is to decide which firms are the incumbents and which are the fringe. It is not as straightforward a task as it appears. The model of equation (10) in Chapter XI, section A, is based on dominant incumbent firms and a contingent of “fringe” firms. Thus entry is less the sudden appearance of new firms in the market, although that could very well be the case, but more of an encroachment of fringe firms already operating, although at marginal levels, in the dominant firms’ market. The question becomes which are the fringe firms and which are the dominant firms. Research by Clyde and Reitzes, revealed that tacit collusion among carriers is more important than conference membership in setting freight rates. This is an artifact of the 1984 Shipping Act, which stipulated that conferences allow “independent action” for individual members. The Act also allows conference and non-conference carriers to form “discussion agreements” in which the general level of service and prices are discussed but no binding commitments are required. Yet there can be no denying that a consortium of firms that hold a majority market share should have some ability to affect the behavior of fringe firms if there are explicit provisions barring collusive behavior. Therefore, carriers belonging to either a conference or a discussion agreement will constitute the incumbent

firms. Firms not a party to either arrangement will be considered in the competitive fringe.

The second issue is that of geographic market definition, particularly whether to consider direction of trade separate from the trade route as a whole. In other words, are exports from *A* to *B* a separate market than exports plus imports from *A* to *B*? The inclination is to break out the trade by direction for two reasons. First, macroeconomic conditions will differ among trade partners, and second, liner carriers are not necessarily restricted to import-export sailings. They may take imports from country *A* to country *B*, then take country *B*'s exports to country *C*, before returning with *C*'s exports to *A*. Hence the model will treat import and export markets as distinct.

There are 12 trade lanes included in the sample:

- 1) Trans-Pacific (Imports/exports)
- 2) North Atlantic (Imports/Exports)
- 3) Mediterranean (Imports/Exports)
- 4) Red Sea/Middle East (Imports/Exports)
- 5) Oceania (Imports/Exports)
- 6) West Coast South America (Imports/Exports)

It was decided not to separate the Trans-Pacific into Northeast and Southeast Asia because both trade lanes are governed by the same conferences. The same for the Red Sea/Middle East trade lanes, which include India and the subcontinent, the Persian Gulf and the rest of the Middle East except North Africa. The Trans-Pacific is China, Taiwan,

Japan, Korea, Hong Kong, Thailand, Malaysia, Indonesia, Singapore and The Philippines. The North Atlantic trades include all of Eastern and Western Europe plus Scandinavia. The Mediterranean includes Spain, Portugal, Italy, Greece and Turkey as well as Gibraltar, Cyprus and Malta. The West Coast of South America is Chile, Peru, Ecuador and Colombia. The East Coast of South America, Central America and the Caribbean trades are excluded because their high level of transshipments makes the capacity calculation unreliable.

Table V below contains the means of the percentage incumbent excess capacity by trade lane. The trade imbalances can be readily seen. In the outbound Asian trades, excess capacity is nearly double that for inbound trade. Trans-Atlantic trades exhibit a smaller imbalance and the Middle East/Red Sea, West Coast South America and Oceania trade are relatively balanced.

Table V. Mean incumbent excess capacity as a percent of total capacity by trade lane: Sample includes the fourth quarter of 1992 through the fourth quarter of 2000.

Direction	Asia	N Eur	The Med	Red Sea/	WCSA	Oceania
Exports	38.9	38.2	34.1	31.3	38.9	55.1
Imports	21.8	30.8	25.3	29.4	38.6	57.5
Obs	33	33	33	33	33	33

The model to be estimated is intended primarily to extract the preemption parameter $\frac{1}{1-k}$ derived in equation (10) of chapter XI. It will attempt to estimate the effects of changes in fringe firm capacity on incumbent excess capacity, holding all other variables discussed thus far constant. The data is a pooled cross section with

observations in 12 panels from the fourth quarter of 1991 through the fourth quarter of 2000. A four-quarter lag on the price of new vessels will reduce the number of observations per panel to 33. Endogenous variables are likely to pose an estimation issue. There are two potential sources of endogeneity: fringe firm capacity and incumbent concentration. With respect to the former, while excess capacity of conference carriers is hypothesized to be a function of fringe firm expansion, it is also the premise of this model that that fringe firm expansion is anticipated to be a function of conference excess capacity. With respect to the latter, increased concentration among incumbents should ease conditions under which incumbents can coordinate the decision to raise excess capacity as a strategic defense against fringe firm entry or encroachment. Moreover, in incumbent groups that are highly concentrated, the responsibility for carrying excess capacity may fall heavily upon the largest members with the deepest pockets. Dominant members may even undertake this action unilaterally. If this is the case, then it can be expected that the dominant carriers will reap most of the benefits, in which case their share of demand will rise at the expense of both fringe firms and other incumbents. In this case, concentration among incumbents will thus also rise. The question is why any incumbent would carry costly excess capacity if the benefits have to be shared with all other members. The answer is that in the case of liner shipping, the benefits do not necessarily accrue equally to other liner conference members. Liner conferences do set prices but they also compete among themselves on service.

Evidence of endogenous variables can be revealed with the Durbin-Wu-Hausman (DWH) test.⁶⁹ If the test reveals evidence of endogeneity, ordinary least squares is not consistent. Instead, the model requires a two-stage estimation procedure. Either fringe firm capacity or incumbent concentration is first estimated as a function of all the exogenous variables in the model, and then the predicted values from those estimations are used to estimate the conference excess capacity equation. In addition, there is likely to be cross-sectional or contemporaneous correlation, since economic variables that affect one trade lane are likely to affect another. For example, the shock to the global financial system that began in Asia spread quickly to other emerging markets, such as Brazil and Russia. Finally, given the number of time periods, autocorrelation of the residuals may pose another estimation problem.

There are two approaches that may be used to overcome these estimation issues. The first is a systems method of estimation. In a systems approach, the equations of the model are stacked and estimates of their parameters are obtained simultaneously. Seemingly Unrelated Regression (SURE) and three stage least squares (3SLS) are two systems methods that may be appropriate for this study. SURE accounts for heteroskedasticity and contemporaneous correlation of the residuals. This method is, however, inappropriate when there are endogenous variables in the system. In this case, 3SLS, the systems analog to two stage least squares, is the preferred method.

The second approach will make use of random and fixed effects models. If there are endogenous variables in the current specification, it will require an instrumental

⁶⁹ The Durbin-Wu-Hausman test is an augmented regression test. In it, the suspected endogenous variables are regressed on all the exogenous variables in the model. The residuals are saved and used in a regression of the

variables estimator. Instrumental variables (IV) use the exogenous variables in the model to predict the values of the endogenous variable, or that variable thought to be closely related to the error term. In STATA version 7.0 there is a canned IV method for estimating random and fixed effects panel data models. However, STATA's IV program does not allow for an autocorrelation correction. Hence the model will have to be estimated in steps.

The following denotes the variables in the model:

K_f = fringe firm capacity (KFRNG)

K_e = incumbent excess capacity (PKEXC)

K_p = incumbent productive capacity (CONFK)

SHCONF = the share of demand held by the conference⁷⁰

DD = volume of trade in TEUs

IMB=Trade imbalance per trade lane by volume in TEUs (Import TEUs - Export TEUs).

CONC = the four-firm concentration ratio within the conference

DMAX = the four quarter maximum deviation of demand from its long-term growth rate

NEWBLD = the average real price in 1996 U.S. \$'s of new vessels of 3,000 TEU capacity and above⁷¹

original model. If the errors are correlated, the t-statistics on the coefficient of the saved residuals of the suspected endogenous variable will be statistically different from zero.

⁷⁰ Conference membership was determined in most cases by identifying the particular ship line and its vessel capacity through the PERS database and then tracing that ship line's conference membership through archives of the maritime trade press, including *Containerization International*, *The Journal of Commerce*, *Infomare* and *Lloyd's List*. Additional sources were the Federal Maritime Commission and the U.S. Maritime Administration. In the case of the Trans-Pacific trades, conference/discussion group membership was obtained directly from the conferences themselves.

OSRA = Dummy variable to test for the effect of the Ocean Shipping Reform Act of 1998 Equal to one from second quarter, 1999 to end of sample and zero otherwise

CVOY = Voyage count of incumbents

All data is sourced from the PERS database except for NEWBLD, which is sourced from Lloyds Maritime Information Services, Ltd., United Kingdom.

The equation(s) to be estimated is the following:

$$1) K_{et} = a_1 + a_2 * K_{lt} + a_3 * K_{pt} + a_4 * NEWBLD_{(t-4)} + a_5 * IMB_t + a_6 * DMAX_t + a_7 * OSRA + a_8 * CONC_t + a_9 * DD_t + a_{10} * TIME + SEASONAL DUMMIES,$$

Since fringe firm capacity and/or incumbent concentration are believed to be endogenous, it will require a second equation composed of all the exogenous variables in the first equation plus an instrument for either endogenous variable. The predicted values from these regressions are substituted for the actual values in equation (1). The search for an appropriate instrument is a key element of simultaneous estimation. If the chosen instrument does not display a statistically significant relationship with the endogenous variable, the problem of weak instruments can produce biased results.⁷² In the case that fringe firm capacity is endogenous we have equation (2) and in the case of incumbent concentration, we have equation (3).

⁷¹ This series was formed with annual data supplied by Lloyds Maritime Information Services. The annual data was converted to quarterly data by using the quarterly price deflator on each annual observation.

⁷² See Bound, Baker and Jaeger (1995).

$$2) K_{it} = b_{1it} + b_2 * K_{pit} + b_3 * SHCONF_{it} + b_4 * CVOY_{it} + b_5 * IMB_{it} + b_6 * DMAX_{it} + b_7 * OSRA + b_8 * NEWBLD_{(t-4)} + b_9 * DD_{it} + b_{10} * CONC_{it} + b_{11} * TIME + SEASONAL DUMMIES$$

$$3) CONC_{it} = c_{1it} + c_2 * K_{pit} + c_3 * CVOY_{it} + c_4 * SHCONF_{it} + c_5 * IMB_{it} + c_6 * DMAX_{it} + c_7 * OSRA + c_8 * NEWBLD_{(t-4)} + c_9 * DD_{it} + c_{10} * K_{it} + c_{11} * TIME + SEASONAL DUMMIES$$

where i indexes the trade lane and t indexes the time period. In equations (2) and (3) the instruments are the share of demand held by the conference and the conference voyage count. The case can be made intuitively that conference share of demand will have a negative impact on fringe firm capacity, since in this two-player market, any gain in incumbent share must come at the expense of fringe firms. If fringe firms are losing share then they will withdraw capacity. For equation (3) the incumbent voyage count (CVOY) is calculated to account for vessel sharing agreements and alliances. It is the aggregate sum of the number of steamship lines and regions represented by a single vessel voyage. In other words, if there are two firms carrying cargo aboard one vessel, then that vessel call represents two voyages. If each firm carried cargo from two separate regions, then the voyage count rises by a factor of 2. The relationship between voyages and concentration is anticipated to be negative. As the number of voyages made by incumbents rises, we expect the concentration ratio within the incumbent group to fall since the largest percentage increase in voyages should accrue to the smallest carriers

within the conference. Since there are two instruments and two endogenous variables, the equation for incumbent excess capacity is exactly identified.

The signs of the coefficients are anticipated to be as follows:

$a_2 > 0$ - incumbents add excess strategic capacity when fringe firms expand or threaten to expand, all else equal.

$a_3 > 0$ - this parameter reflects the lumpiness of capacity and is an approximation of the empty core effect. When incumbents add capacity, they necessarily add to excess capacity because additions to capacity are large relative to demand requirements.

$a_4 < 0$ - the higher the price for large vessels, the lower is excess capacity. This effect may work through productive capacity since productive capacity should be governed by prices as well.

$a_5 > 0$ - a higher trade imbalance should cause excess capacity to rise on the “light” leg of the journey.

$a_6 > 0$ - when demand is volatile, incumbents have incentive to keep reserve capacity available to cover unanticipated spikes. Incumbents observe past deviations from the long-term trend rate of growth and add capacity as positive deviations rise.

$a_7 < 0$ OSRA permits the signing of long-term confidential and volume-based contracts.

This should serve as a barrier to entry in and of itself and will give carriers less incentive to carry excess capacity as a strategic deterrent.

$a_8 > 0$ - as the level of concentration within the conference rises, conference carriers are better able to impose behavioral constraints on their members, including investment in entry-detering capacity.

$a_9 < > 0$ - rising demand will cause excess capacity to fall, in which case it is negative. However, rising demand will induce entry and may compel incumbents to add to excess capacity to deter it.

$a_{10} > 0$ - time is a proxy for technical change. Larger and faster vessels may increase capacity before demand conditions warrant it.

XIV. Results

Three Stage and Ordinary Least Squares

The dependent variable is excess capacity among incumbents estimated as a percent of their available capacity. This imposes a degree of standardization across trade lanes with heterogeneous trade patterns. As a result, the equations may be restricted to have a single constant term. A DWH specification test for endogeniety in equation (1)

was performed on fringe firm capacity and incumbent concentration. The results indicate that both fringe firm capacity and incumbent concentration are correlated with the errors in equation (1). The equations were run using the random effect estimator in STATA with a first order autoregressive correction. OLS is run separately on each variable suspected of endogeneity against all the exogenous variables in the model. The residuals from these regressions are retrieved and then added to the full regression of incumbent excess capacity, again using OLS. A Wald test is performed on the coefficients of the two residual variables. If they are jointly significant, then the errors in the full equation for incumbent excess capacity are correlated with the dependent variable. The results of this test are reported in Table VI below.

Table VI. Durbin-Wu-Hausman test for endogeneity of fringe firm capacity and incumbent concentration.

Suspected Endogenous Variable	Coefficient	t-Statistic
Fringe Firm Capacity Residuals	2.12e-06	8.48***
Concentration Residuals	0.281	3.53***

Joint Wald Test Chi Sq = 36.02, Pr >Chi Sq=0.0000
 * indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

Separately, the results suggest that fringe firm capacity is endogenous but concentration is not. When tested jointly, however, the Wald statistic returns a highly significant result. Hence, an equation for incumbent excess capacity that contains fringe firm capacity and incumbent concentration will require a two-step estimator using the instruments incumbent voyages and incumbent share of demand. The OLS results will be reported along side.

The first model presented is the restricted three stage least squares (R3SLS), available in EVIEWS. Equations (2) and (3) above are estimated in the first stage by ordinary least squares (OLS). The predicted values of the endogenous variables from the OLS regression are then used to compute the two-stage least squares parameters and the estimated variance-covariance matrix to correct for cross-equation correlation. In the third stage the variance-covariance matrix is used to compute the generalized least squares (GLS) estimates of the parameters. The results of the third stage are reported in Table VII. below, as well as results for OLS. All of the equations in the system reported autocorrelation and were adjusted with the addition of a first order autoregressive parameter that was allowed to vary across equations. All of the other parameters are restricted to be equal across all equations.

Table VII. OLS and R3SLS results - incumbent excess capacity (in percent).

Variable	PKEXC/R3SLS	t-statistics	PKEXC/OLS	t-statistics
KFRNG	5.67e-07	17.98***	5.51e-07	6.34***
CONC	-0.055	-1.49	0.003	25.09***
DD	-8.14e-07	-31.82***	-8.46e-07	-10.39***
NEWBLD(-4)	-0.0002	-0.349	-.001	-1.41
IMB	3.37e-08	2.15**	5.25e-08	1.10
CONFK	5.53e-07	25.08***	5.94e-07	9.17***
DMAX	-0.040	-1.41	-0.116	-3.14**
OSRA	0.005	0.752	-0.008	-0.707
TIME	0.0004	0.453	-0.002	-0.998
Constant	0.319	2.50**	0.604	2.48**

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

Table VIII below reports the coefficient on CVOY in the first stage regression of concentration on all the exogenous variables and subsequently Table IX reports the

results for the coefficient on SHCONF in the first stage regressions of fringe firm capacity on all the exogenous variables by panel. There are 33 observations per panel reported.

Table VIII. Strength of instrument (CVOY) in first stage regression of incumbent concentration in three stage least squares model.

CVOY	Asia	N Eur	The Med	Red Sea/	WCSA	Oceania
Exports	-7.30E-05*	-0.0003**	-0.0016***	-0.0017**	-0.0005	-0.0005
Imports	1.93E-05	-0.0005***	-0.0007**	-0.0007	-0.002**	-0.0002
Observations	33	33	33	33	33	33

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

Table IX. Strength of instrument (SHCONF) in first stage regression on fringe firm capacity in three stage least squares model (coefficients in 000s).

SHCONF	Asia	N Eur	The Med	Red Sea/	WCSA	Oceania
Exports	-1,147.1***	-511.5***	-188.6***	-37.5***	-58.1***	-6.6
Imports	-1,330.4***	-322.6**	-184.6**	-31.5***	-33.0**	-88.8***
Obs	33	33	33	33	33	33

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

The equations in Tables VIII and IX are run for each panel for which there are 33 observations. A correction for first order autocorrelation was included in the regressions. With respect to the concentration equation, the voyage count has the expected sign in each panel except for eastbound Trans-Pacific. It loses statistical significance in five of the twelve equations, likely because there is relatively little variation in incumbent concentration on those lanes, and second, because there is collinearity between conference share of demand and conference voyages. For the eastbound Trans-Pacific, a four quarter lag on demand was substituted for the voyage count. The sign was negative as expected since the four-quarter lag allows both new entrants and existing, smaller

firms within the conference sufficient time to penetrate larger conference firms' market.

The t-statistic for this instrument was 1.91 with an associated p-value of 0.03.

Unfortunately, this substitution failed to produce satisfactory results for the remaining four panels where the voyage count proved to be a weak instrument. For the two Oceania routes, the t-statistics were 0.90 for imports and 1.16 for exports. Their associated p-values were 0.38 and 0.26 respectively. For the southbound West Coast South America panel, the t-statistic was 0.97 with an associated p-value of 0.34. The t-statistic for the northbound Red Sea/Middle East panel was 0.81 with a p-value of 0.42. The voyage count is a weak instrument in these cases, however, given that these trade lanes are relatively less important in the aggregated data, it was decided to allow the use of voyage count as an instrument for incumbent concentration.

The instrument for fringe firm capacity, conference share of demand, on the other hand, was universally strong. The coefficients each have the expected sign and their associated t-statistics are all significant, at least at the 95% level. This partially reflects the inter-group switching behavior made possible by the 1984 Shipping Act. Fringe firms that join conferences take away from aggregate fringe firm market share and add to conference market share.

The R3SLS and OLS models differ substantially in many regards but there are some similarities. In both specifications, the coefficient on fringe firm capacity is positive, suggesting preemption as a cause of excess capacity. When fringe firm capacity rises, incumbents add to excess capacity, all else equal. The effect is statistically different from zero in both specifications; however, in the R3SLS the t-statistic is approximately three times that of the OLS model. Its overall effect, that is, its effect for all trade lanes

combined in both versions is moderate. The elasticity, evaluated at the overall sample mean is 0.43 in the R3SLS specification and just slightly smaller in the OLS version. The result is well within the inelastic range. While there is no standard by which to judge the magnitude of the response, we would expect that were preemption a major influence on incumbent excess capacity, the elasticity would be much higher. Of course, the restricted model assumes that the propensity to enter (k in equation 10, chapter XI) is the same in each market. Since each market has its own distinct profit opportunities associated with it, the propensity to enter should vary accordingly. The individual market coefficients can be estimated by running the three-stage least squares model and removing the restriction of same coefficients on fringe firm capacity. The results are listed in Table X below.

Table X. Pre-emption effects and their associated elasticities (three-stage least squares).

Trade Lane	Pre-Emption effect	t-statistic	Elasticity
Eastbound Trans-Pacific	5.43e-07	15.90***	0.67
Westbound Trans-Pacific	5.98e-07	22.46***	0.34
Eastbound Trans-Atlantic	8.73e-07	7.52***	0.32
Westbound Trans-Atlantic	6.05e-07	7.88***	0.29
Eastbound The Med	1.69e-07	9.28***	0.03
Westbound The Med	5.52e-07	4.37***	0.20
Northbound India/Middle East	4.68e-06	1.30	0.06
Southbound India/Middle East	1.28e-05	5.26***	0.14
Northbound West Coast SA	4.56e-06	5.38***	0.27
Southbound West Coast SA	6.28e-06	6.24***	0.31
Northbound Oceania	2.13e-05	12.57***	0.54
Southbound Oceania	-2.65e-06	-3.73***	-0.15

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

The results for individual markets are mixed. Coefficients for all markets except for Southbound Oceania have the anticipated sign, suggesting preemption rather than

accommodation. In the case of Southbound Oceania, the length of haul and a significant imbalance between imports and exports make this a very difficult trade lane in which to operate. Incumbents are more likely to accommodate fringe firm entry/expansion than they are to preempt them. In addition, since there is little transshipment in this trade, carriers tend to make direct calls to and from the U.S. The preemption response was relatively large and positive on the northbound leg so that it is possible that entry deterrence on the southbound leg occurs mainly in the northbound market. In terms of elasticities, the strongest preemption response was found in the eastbound Trans-Pacific. Demand on this route is far greater than all other lanes and the cargo tends to be high-value consumer goods that command a relatively high freight rate. This lane is also one of the fastest growing and as a result, k is likely to be very high. Entry is therefore apt to provoke a strong defensive excess capacity reaction on the part of incumbents. The preemption effect in the far less profitable westbound lane was positive but weaker than the eastbound lane. One explanation may lie in the trade imbalance. With significantly lower demand westbound than eastbound, the westbound leg is already burdened with significant and incidental excess capacity. Entry deterrence may be more an artifact of the incidental overcapacity than deliberate preemptive efforts on the part of incumbents. Moreover, cargo heading west to Asia tends to be low-value industrial inputs such as waste paper, metal scrap, resins and so on. These commodities command relatively lower freight rates and as such, profit opportunities are slimmer.

In the North Europe trades, the preemption effect was positive and statistically significant. Their associated elasticities reveal a proportionately weaker response to fringe firm expansion than the Trans-Pacific though it remains a high response relative to

most other markets. Like the eastbound Trans-Pacific, the commodity mix on the westbound Trans-Atlantic tends to be dominated by high-value consumer goods, and is thus more likely to illicit a stronger preemptive response. Eastbound, commodities tend to be lower-value industrial inputs and waste/scrap materials and this is reflected in the smaller preemption response. In addition to demand characteristics, government assistance to maritime carriers in the North Europe trades is a less prominent feature of the liner shipping industry than it is in the Trans-Pacific market. Thus the propensity to enter should be relatively small, requiring incumbents to react only moderately when an entry threat is revealed. Finally, in the North Europe trade lanes, liner conferences, until very recently, were known to be very cohesive and stable arrangements. This in and of itself might be sufficient to deter entry since a stable well-behaved conference is a credible threat to act aggressively and in concert against potential entrants.

There is a strong and positive preemption effect in the westbound Mediterranean trade, however, the eastbound leg shows virtually no response. Again, this may be explained by the profit opportunities. Westbound trade from this region is dominated by high-value goods such as upscale furniture, apparel, auto parts and so on. Eastbound, the trade is more likely to be cotton, resins and other lower-value industrial inputs. It is natural then to expect stronger preemptive behavior westbound than eastbound since there is more at stake westbound.

The preemption effect in the Middle East/Red Sea trades follows the same pattern as the Trans-Pacific, and the Mediterranean. In the southbound leg, where cargo is of higher-value commodities, the preemption effect is strong. Northbound, the preemption effect does not differ, statistically, from zero.

Finally, in both directions of the West Coast South America trade, incumbent reactions to fringe firm expansion/entry are moderately strong in relative terms. The northbound leg of this trade is dominated by agricultural commodities and seafood, the production and export of which are highly volatile. This volatility creates conditions for hit and run entry, which creates a need for entry-detering behavior. Southbound, trade volume is also relatively unpredictable since the economies in this region tend to be unstable relative to other regions of the world. Again, volatility breeds conditions for hit and run entry that requires a fairly strong preemptive strategy.

In sum, incumbents appear to expand excess capacity only moderately on most trade lanes in response to fringe firm entry/expansion. The exception is the profitable eastbound Trans-Pacific where the elasticity of incumbent excess capacity with respect to fringe firm expansion was 0.67. The results suggest that entry deterrence is an element of excess capacity among incumbents in liner shipping, but it is probably not the dominant cause. Incumbents do add excess capacity to defend against fringe firm expansion in most markets but at proportionally lower increments.

Returning to the R3SLS model, the coefficient on incumbent concentration is negative. This suggests that in and of itself, incumbent concentration is a sufficient barrier to entry because tighter oligopolies signal a credible threat to increase output when the threat of entry is revealed. Hence there is less need to carry strategic excess capacity to forestall entry. This follows the results arrived at by Esposito and Esposito (1974) and Gilbert and Vives (1985). However, the coefficient is not statistically different from zero, and thus the result has to be viewed with caution. In the case of OLS, concentration has the opposite sign. This is likely because there is a rise in concentration when the largest

firms (with the deepest pockets) in the conference deploy larger and more vessels to capture demand. The deployment of larger vessels, as will be seen in the productive capacity effects, necessarily raises excess capacity via the empty core hypothesis to be discussed in more detail below.

With respect to demand, in both versions, the effect is negative as expected and highly significant. First, one would expect that holding incumbent capacity constant, a rise in demand should reduce excess capacity, because it forces a substitution to productive capacity in order to satisfy demand. However, demand is closely collinear with incumbent productive capacity (correlation coefficient of 0.99) and with both variables in the same equation it is difficult to quantify the effect of demand separate from productive capacity. A separate three stage least squares system that includes demand but excludes incumbent productive capacity reveals a smaller coefficient (-2.52e-07), but it retains the correct sign and statistical significance. Thus, at least a fraction of the demand parameter can be attributed to its relationship to incumbent productive capacity, but not all.

There is limited support for the empty core approach and limited support for Sharkey's dynamic capacity expansion problem in the coefficient on conference productive capacity. This coefficient is positive and highly significant. Its associated elasticity in the R3SLS version is moderate - 0.42 and slightly larger in the OLS version. This result suggests that when carriers deploy new productive capacity it necessarily raises excess capacity and is strong evidence of an inefficient matching of supply and demand predicted by an application of the theory of the core to liner shipping markets.

In terms of natural monopoly, a fairly direct approximation is found in the parameters on IMB and DMAX. The coefficients on IMB are consistent with the natural monopoly argument but the negative signs on DMAX are not. Were liner shipping a natural monopoly, we would have expected a positive coefficient on DMAX as carriers deploy capacity to cover anticipated spikes in demand. However, it does not appear from these results that excess capacity in liner shipping is a result of the industry's tendency towards natural monopoly, at least not based solely on demand conditions.

Because average capacity per vessel is too closely correlated with incumbent productive capacity, technical change is approximated with a simple time trend. This parameter is positive in the R3SLS version but insignificant. In the OLS version, TIME is negative and insignificant. These results indicate that excess capacity among incumbents as a percentage of their total capacity is constant over time. The results are consistent with casual observation of the industry. During the sample period, there has been a marked increase in the rationalization of services among incumbents. Vessel sharing agreements, as was made clear previously in Chapter II, have been rising steeply over the past ten years. Since time is a "catch-all" variable, it is likely that it is picking up the dampening effects on excess capacity of vessel sharing, which dominate the positive effects of the introduction of increasingly larger ships.

Finally, the effect of OSRA is positive in the R3SLS version and negative in the OLS version. In neither case is the effect statistically significant. According to the model, the legislation has thus far had no discernable effect on incumbent excess capacity.

The above R3SLS model accounts for cross-equation correlation, autocorrelation and endogenous variables. A problem with three stage least squares is, however, that if there is a specification error in one equation, that error may corrupt the results of all of the other equations as well. Hence, in the next section, the results of the R3SLS model are checked by running the same equation(s) as a random effects model with instrumental variables.

Random and Fixed Effects with Instrumental Variables

In the random effects model, there is a single constant term that carries a distribution across panels. In the fixed effects model, differences across panels can be viewed as shifts in the constant term. It must first be determined which specification, either the fixed or the random effects, is appropriate. The general form of a pooled time series model is $Y_{it} = \alpha + Xb + v_i + e_{it}$. The errors have two components; v and e . The v component is the error associated with the i^{th} panel and the e is associated with both the panel and the time element. A random effects model assumes that the expected value of the v component is zero but the variance of $v > 0$. Otherwise, v would be a constant. Hence, to make the case for a random effects model, we need a test for the significance of the variance of v . For this, the Breusch-Pagan or LaGrange multiplier test is appropriate. Running the test of the variance of v in the data yields a chi-square of 2,749.6, which is statistically significant from zero. Hence, the results suggest that the random effects model is appropriate.

Because it conserves degrees of freedom, the random effects model is preferable to fixed effects. Confirmation of the specification of the model is available through the Hausman specification test. In this test, the coefficients of the random and fixed effects models are compared. If they do not differ statistically, then it suggests that the model is correctly specified. Results are reported in Table XI. below.

Table XI. Hausman specification test –fixed effects versus random effects

Coefficient	Fixed Effects	Random Effects	Difference
Demand	-7.47e-07	-7.22e-07	-2.49e-08
Concentration	0.077	0.057	-0.134
Imbalance	1.52e-08	2.66e-08	-1.14e-08
Conference Capacity	5.84e-07	5.34e-07	4.99e-08
DMAX	-0.134	-0.116	-0.018
OSRA	0.009	0.007	-0.002
Newbld(-4)	-0.002	-0.002	0.001
Time	-0.003	-0.003	0.001
Q1	-0.005	-0.009	0.004
Q2	-0.016	-0.017	0.001
Q3	-0.004	-0.006	0.002
Fringe Capacity	5.23e-07	2.43e-07	2.81e-07

Chi Squared = 80.21, Pr > Chi Squared = 0.0000

Under the assumption that the efficient model is fixed effects, the Hausman test suggests that the difference in the coefficients is systematic. Particularly worrisome is the large difference in magnitude for the fringe firm capacity coefficients and the alternating sign on concentration. This casts doubt on the appropriateness of the random effects model, in spite of the Breusch-Pagan results reported above. The difference is likely the result of the autocorrelation error. Under the assumption that the random effects specification is the fully efficient model, another Hausman test with the autoregressive

correction available in STATA reduces the Chi Squared to a more reasonable level, and also narrows the difference in magnitude between the fringe firm parameters. The results are reported in Table XII below.

Table XII. Hausman test with autoregressive correction.

Coefficient	Fixed Effects	Random Effects	Difference
Demand	-8.09e-07	-7.93e-07	-1.15e-08
Concentration	-0.080	0.011	-0.091
Imbalance	1.31e-08	2.46e-08	-1.15e-08
Conference Capacity	6.39e-07	5.59e-07	7.96e-08
DMAX	-0.128	-0.129	0.0001
OSRA	0.003	-0.003	0.0005
Newbld(-4)	-0.001	-0.002	0.0004
Time	-0.002	-0.002	0.0004
Q1	-0.003	-0.006	0.0009
Q2	-0.014	-0.015	0.001
Q3	-0.003	-0.004	0.0004
Fringe Capacity	6.25e-07	4.25e-07	2.00e-07

Chi Squared = 18.64, Pr > Chi Squared = 0.017

Since the differences in coefficients are still systematic, the results of the fixed effects model will be reported alongside the random effects results in Table XIII.⁷³

⁷³ The Hausman test was also run using the predicted values of the two endogenous variables - fringe firm capacity and incumbent concentration. The results were similar to Table XII.

Table XIII. Random effects and fixed effects with instrumental variables - results

	Random Effects	z-statistic	Fixed Effects	t-statistic
Variable	PKEXC		PKEXC	
Constant	0.790	3.22**	0.486	3.46**
KFRNG	4.66e-07	2.10**	8.01e-07	3.06**
DD	-7.09e-07	-6.43***	-8.18e-07	-6.75***
CONC	0.123	2.33**	0.131	2.24**
IMB	3.79e-08	0.92	6.23e-08	1.49
NEWBLD(-4)	-0.002	-1.98**	-0.002	-2.13**
CONFK	4.70e-07	6.62***	5.16e-07	6.00***
DMAX	-0.133	-3.36**	-0.121	-3.00***
OSRA	-0.004	-0.30	-0.004	-0.35
TIME	-0.003	-1.88*	-0.002	-2.28**
R-Squared	0.31		0.23	
Wald-Statistic	116.2***			
F-Stat (12,360)			9.25***	
AR(1)	0.465		0.465	
Obs per Group	33		32	
Total Obs	396		384	

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

Both the random effects and fixed effects models provide a reasonable fit and with the exception of a change in sign on incumbent concentration, time and OSRA, the results are generally consistent with the R3SLS model. The fringe firm parameter and the trade imbalance parameter in the random effects are nearly one-half smaller than in the fixed effects specification, but the remaining coefficients are of approximately the same magnitude. The results confirm that incumbent firms react to entry and expansion of the competitive fringe. The elasticity measured at the sample means in the random effects model is 0.352, just a shade weaker than in the R3SLS model. In the fixed effects its elasticity is 0.604, significantly larger than in the R3SLS but still less than one.

The sign of the coefficient on demand in both specifications is negative as expected and just slightly smaller in absolute value than in the R3SLS model.

In both the random effects and fixed effects models, the coefficient on incumbent concentration conflicts with the R3SLS and changes to positive. However, increased concentration is the result of an increased share of volume carried by the top four firms in the conference. In order to increase share, the top carriers must deploy larger vessels, which the model has suggested necessarily increases excess capacity because it is virtually impossible to exactly, match demand with supply in this industry. The positive coefficient on concentration may be picking up the effects of core emptiness and is incidental to excess capacity. Concentration is thus collinear with productive capacity. Removing incumbent productive capacity and re-estimating both the fixed and random effects models returns the negative sign of the R3SLS model while retaining its statistical significance.⁷⁴ This confirms the result that tighter oligopolies facilitate the ability to increase output and as such present fringe firms with a credible, entry-detering threat to do so.

The trade imbalance parameter remains positive in both the random and fixed effects models but it loses its statistical significance in both specifications. The positive sign supports the natural monopoly hypothesis but the evidence is much weaker than in the R3SLS version. The coefficient on incumbent productive capacity is smaller than in the R3SLS and although it remains highly significant, its standard error rises. This result provides support for Telser's empty core approach since it suggests that capital lumpiness underpins a large proportion of incumbent excess capacity. The elasticity of incumbent

⁷⁴ In the random effects model without conference capacity, the concentration parameter was -0.282 and statistically significant at the 95% level. In the fixed effects model the same regression yielded -0.280 , again, statistically significant at the 95% level.

excess capacity with respect to productive capacity is 0.344 in the random effects and just slightly larger in the fixed effects model.

The coefficient on TIME changed from positive to negative and was statistically significant in both the random effects and fixed effects models. Likely, the TIME coefficient is picking up the effects of increasing levels of service rationalization among incumbent firms through vessel sharing and alliance agreements. It is not necessarily evidence contrary to the theory that liner shipping tends to natural monopoly since it provides no clue as to the effect of technical change before these types of agreements were prevalent in U.S. trade lanes. An apt description of the result of technical change is "learning by doing," that is, incumbents have learned to adapt to increasingly large vessels through cooperative arrangements. A more interesting conclusion might be arrived at with a longer time series.

The sign on the OSRA dummy was not different from zero and the sign of the NEWBLD coefficient was negative as expected.

The results have implications for the application of the contestable markets hypothesis to liner shipping markets. Liner shipping markets as Davies (1986) has advocated may exhibit some degree of structural contestability. Yet, his analysis did not account for behavioral actions by incumbents that could neutralize that contestability. The models reveal that incumbents do carry excess capacity and will add to it when firms in the competitive fringe threaten to expand. Therefore, what on the surface may appear to be a contestable market may not actually be so, particularly if incumbents are permitted to behave jointly to erect artificial barriers to entry. Levine (1987) used this reasoning to

support his denial of the notion that airline markets should be deregulated based partially on the contestable markets hypothesis.

Finally, with respect to the theory of the core, there is strong evidence to support previous studies that indicate the core of liner shipping markets is empty. Because capital can be deployed most cost effectively in large, discrete units, it reduces the probability that supply equals demand at every point in time and in every market. The coefficient on incumbent productive capacity was positive and highly significant in the R3SLS, the random effects with instrumental variables model, and the fixed effects with instrumental variables model. Although its elasticity fell below 1, it is obvious that when productive capacity rises, excess capacity necessarily rises as well. This adds weight to the argument that liner conferences do not exist as price making cartels but may exist as a response to core emptiness.

In sum, there is moderately strong evidence of preemption by means of excess capacity in both the random effects, fixed effects and R3SLS models. Were preemption not an influence, the models would have produced negative or statistically insignificant results.

Finally, it is left to confirm the appropriateness of the instruments chosen to estimate the concentration and fringe firm equations. Table XIV reports the OLS results for the instruments in the first stage of the random effects and fixed effects with instrumental variables model. The results indicate that both the voyage count and incumbent share of demand are strong instruments for incumbent concentration and fringe firm capacity.

Table XIV. First stage results - random effects/fixed effects models

Instrument	Endogenous Variable	Coefficient	t-statistic
SHCONF	KFRNG	-171,121.7	-15.18***
CVOY	CONC	-0.001	-17.21***

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

What do these results imply about competition in liner shipping? That is, does competition follow the Bertrand, Cournot, or the cartel model? Since there is evidence to support the theory that excess capacity is used to deter the entry and expansion of fringe firms, competition in liner shipping markets are likely to follow Bertrand. However, inferences based on the excess capacity equations alone, are not sufficient to make that claim. The conjectural variations approach requires another regression to retrieve the conduct parameter. Instead of excess capacity, the dependent variable is total incumbent capacity and the conduct parameter is $\frac{dK_I}{dK_F}$.

Traditional conjectural variations models look at output choices. Using capacity is a non-conventional approach that needs to be explained. In the case of liner shipping, the choice of capacity is essentially a choice of output. Transport is a derived demand and carriers have very little influence over what and how much is traded. In other words, output in terms of volume of traded cargo can be considered almost entirely exogenous.⁷⁵ Carriers do not produce the cargo, but they do produce the transport services required by importers and exporters of cargo. In the fixed schedules environment of liner shipping, firms announce a particular schedule of service that can be considered a particular level of

⁷⁵ In some limited cases, carriers can induce trade by lowering freight rates to such a level as to make the transport of low-value cargo economically feasible. This applies mainly to what are known in the industry as "swing cargo." They include such commodities as waste paper, industrial resins, scrap metal and so on. In general these are commodities with very low price inelasticities.

output. The output chosen is the capacity required to produce that output, regardless of the level of demand. Hence, in liner shipping, the choice of capacity is essentially the choice of output and as such can be used in a conjectural variations model.

As in the excess capacity equations, the total incumbent capacity may require a two-stage estimator since fringe firm capacity is likely to be endogenous. However, the results of a DWH test in Table XV below refute this suspicion. Hence, the estimation can proceed without need for instrumental variables.

Table XV. DWH Test for endogeneity of fringe firm capacity in a model of total incumbent capacity.

Endogenous Variable	F-Statistic
Fringe Firm Capacity (Residuals)	1.13

* indicates statistical significance at the 90% level, ** at the 95% level and *** at the 99% level.

The econometric specification is;

$$\text{Incumbent Total Capacity} = d_1 + d_2 \text{KFRNG} + d_3 \text{DMAX} + d_4 \text{IMB} + d_5 \text{NEWBLD} + d_6 \text{OSRA} + d_7 \text{DD} + d_8 \text{TIME} + d_9 \text{CONFLINES} + \text{Quarterly Dummies} + \text{AR}(1)$$

Note the addition of CONFLINES, or the number of conference member ship lines. This will control for the effects of switching behavior of firms between fringe and conference. As was discussed earlier, the Merchant Shipping Act of 1984 eased conditions for individual carriers to both enter and exit liner conferences. Hence an increase in incumbent total capacity may be a result of adding fringe firms to their ranks rather than as an attempt to gain first mover advantage. Conversely, a decrease in incumbent total capacity may be individual firms resigning.

Since we are only interested in the conduct parameter, d_2 , it is reported in Table XVI below. With respect to specification, a Hausman test returned a chi-squared of 6.11, which is not statistically significant. The random effects model is thus adequate; however, the fixed effects results are reported as well. The conduct parameter is retrieved with a correction for a first order autoregressive process. The Wald test is used to determine whether the conduct parameter is statistically different from -1.

Table XVI. Conduct parameters and Wald tests.

Specification	Conduct Parameter	Coefficient	t-statistic ⁷⁶	Wald Test
				$dK_I/dK_F = -1$
Random Effects	dK_I/dK_F	-1.08	-14.54***	0.00
Fixed Effects	dK_I/dK_F	-1.00	-12.24***	1.11

If the inverse relationship between capacity and liner freight rates holds, both the random effects and the fixed effects models with instrumental variables suggest that competition in liner shipping between incumbent and fringe tends strongly towards Bertrand. The Wald test confirms that the conduct parameter is not statistically different from -1 in both specifications. This suggests that the reaction functions can be overlain as would be expected in Bertrand competition. The conjectural variations results add credence to the findings of the strategic element of excess capacity since in Bertrand equilibrium; firms believe they can affect decisions of their rivals.

The conjectural variations results also have implications for the stability of price and supply in liner shipping markets. The degree of instability in the liner market depends on the propensity of fringe firms to enter. In Chapter XI, it was theorized that the larger is the propensity to enter, the more unstable the system becomes. This is

⁷⁶ In the random effects model, STATA reports the z-statistic.

predicated on the hypothesis that incumbent behavior is aggressive. The conduct parameters above and the results of the excess capacity equations confirm that incumbent behavior is indeed aggressive. Incumbents can be expected, therefore, to contribute to excess capacity when fringe firms enter or expand. Liner shipping capacity will consequently be unstable with wide swings relative to demand over time.

XV. Conclusion

Excess capacity is blamed in large part for the poor financial performance and economic inefficiency over the long-term history of the liner shipping industry. An attempt was made in this dissertation to differentiate and quantify excess capacity that may be the result of strategic behavior among incumbent firms, and that which may emerge from the peculiarities of the industry. The latter include the industry's tendency towards natural monopoly, the perceived lack of a competitive core, and non-market forces such as government intervention in liner shipping markets.

Following the previous theoretical works of Spence, Gaskins and others, a model of excess capacity as a strategic entry deterrent was constructed and then estimated using both three-stage least squares and random and fixed effects with instrumental variables. The results suggest that strategic entry-detering behavior is an element of excess capacity in ocean liner shipping markets. Incremental capacity reactions of incumbents to increased demand are disproportionate because increased demand also attracts entry and expansion in the competitive fringe. The excess capacity of incumbents is meant to

forestall fringe firm encroachment by saturating the market and reducing fringe firm profit opportunities.

But entry deterrence is of secondary importance to the theory of the core in explaining excess capacity in liner shipping. The primary determinant of excess capacity in liner shipping is the lumpiness of liner shipping capital. Additions to productive capacity in this industry are large relative to demand and must be made in discreet units. Simply put, when incumbents add capacity to their markets, excess capacity necessarily rises. This condition may be tolerated by incumbent operators because larger vessels capture economies of scale and thus provide lower units costs. This supports Telser's empty core approach in describing imperfectly competitive markets, and also lends credence to Sharkey's dynamic capacity expansion problem that characterizes natural monopoly markets. Other indicators of natural monopoly, such as the trade imbalance between imports and exports, technical change and demand volatility fail to provide more universal support in the application of the theory of natural monopoly to liner shipping markets. In fact, there was no convincing evidence in this model that excess capacity is a result of natural monopoly, unless one believes that an industry with an empty core is a salient characteristic of natural monopoly.

With respect to the theory of contestable markets, the results show that even if liner shipping markets are structurally contestable, a concept that is unresolved, strategic behavior of incumbent firms reduces its degree. Excess capacity may even induce independents operators to switch to conference membership in its particular trade if the conference's excess capacity sufficiently reduces the independent's profit opportunities.

The implications of these results for maritime policy are predicated on the notion that excess capacity is necessarily inefficient, and that improving the flow of international liner trade requires that it be minimized. Any policy would necessarily be required to balance the interests of shippers and carriers. Shippers prefer excess capacity because it increases their choices and lowers their prices. The effect of excess capacity on carriers, however, is likely to raise its fixed and reduce profits. Absent inefficient subsidies, this could eventually present a long-term threat to the viability of the industry in its current form. Instead, there is apt to be increased consolidation among incumbent carriers seeking rationalization of their capacity and subsequently an increased risk of anti-competitive behavior that is detrimental to shippers.

First, it is clear that there is a certain amount of excess capacity in liner shipping that will have to be tolerated, since it arises from the specific characteristics of the industry and the capital it employs. Container vessels are lumpy pieces of equipment that when deployed in a fixed and committed schedule, are unlikely to always operate at maximum load factors. That being said, the one real variable that policy can affect is entry. Inefficient entry, i.e. entry that poses a competitive threat to incumbents without providing compensating benefits to shippers should be minimized. Efficient entry, on the other hand, should be encouraged. On the surface, this conclusion seems to be stating the obvious. Entry restrictions such as licensing fees can in theory provide an adequate response to inefficient entry. Maritime transport, however, confers positive externalities upon countries that operate liner services. Hence, enforcing such restrictions would require a consensus among international players with possibly disparate interests. The question then becomes, should an active policy on competitive entry be eliminated

entirely? In other words, will the market itself be an adequate regulator of competition in liner shipping? Again, this would require that all countries form a consensus to adopt a policy of deregulation, including the elimination of any and all operating subsidies, national ownership of carriers, and the Liner Code of Conduct. In this case, the objective would be to force trade in maritime transport services to follow the ageless comparative advantage model of David Ricardo. A policy of this nature would also have to impose and strictly enforce antitrust rules in case deregulation causes a significant increase in market power of the suppliers.

An efficient and viable liner shipping industry is an important element of international trade, particularly for consumer goods. Given its poor financial performance throughout much of its recent history, liner shipping deserves significant attention from international authorities. In this dissertation, the factors behind what is generally agreed to be one of the most important causes of operating inefficiency in liner shipping were revealed. Clearly, some excess capacity will always exist. However, policy alternatives may exist to minimize that portion of excess capacity that arises from strategic economic behavior, if that behavior indeed reduces total welfare.

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