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ENTRY AND PREDATION: BRITISH SHIPPING CARTELS 1879-1929

Fiona Scott Morton

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ABSTRACT

I examine the outcomes of cases of entry by merchant shipping lines into established markets around the turn of the century. These established markets are completely dominated by an incumbent cartel composed of several member shipping lines. The cartel makes the decision whether or not to begin a price war against the entrant; some entrants are formally admitted to the cartel without any conflict. I use characteristics of the entrant to predict whether or not the entrant will encounter a price war conditional on entering. I find that weaker entrants are fought, where "weaker" means less financial resources, experience, size, or poor trade conditions. The empirical results provide support for the "long purse" theory of predation. I discuss qualitative evidence such as predatory intent expressed in correspondence between cartel members which supports the empirical results. The results are also found to be robust to misclassification of the dependent variable which is a particular concern when dealing with historical data.

Fiona Scott Morton
Graduate School of Business
Stanford University
Stanford, CA 94305-5015
and NBER

1. Introduction

The phenomenon of predatory pricing has interested economists for many years. The idea that a firm might be able to "fight" a rival and cause its exit from the market is dramatic. Analysis shows that conditions necessary for predatory pricing violate some standards of perfect competition, making the possibility of predation controversial. The contradiction inherent in predatory pricing has further motivated the theoretical debate -- low prices in the short term are good for consumers, but in the long term there is the welfare-decreasing effect of less competition.. As social scientists we would like to understand the motivations of the firms acting in our economy. Since predation is a possible and interesting type of behavior, it is worth figuring out under what conditions, if any, we do see it and why.

The Chicago School has argued that predatory pricing is unlikely to be profitable for a firm, much less a group of firms, and will therefore not occur. A firm expecting to gain from predatory pricing must be able to earn excess profits (after the victim's exit) to pay for the price war, but excess profits are inconsistent with perfect competition. More recent models in the game theory literature describe situations under which predatory pricing is rational. One situation is asymmetrical finances, or the long purse story, where war begins because each side believes it has the greater financial resources. Signaling (asymmetric information) is another explanation of predatory price wars. Creation and defense of a reputation can also be a reason for predatory pricing. Theoretical work on reputation has mostly focused on the characteristics of the incumbent (cartel) rather than entrant. However, this paper will concentrate on the type of the entrant and how it affects the probability of predation.

At the turn of the century, British shipping firms operated in cartels that held and defended monopoly positions in various international shipping routes. I construct a dataset for this paper which allows possible incidences of predation by shipping cartels to be examined quantitatively. The dataset consists of cases where an entrant attempted to break in to a cartel and records which entrants precipitated a price war. This paper seeks to understand why some entrants are "fought" and others are not. I describe the practices of the shipping cartels and discuss qualitative factors that make predation a likely response to entry. I also examine entrants' choice of market share to see if it is related to entrant and market characteristics. This unusual opportunity to examine predation is a result of both lack of antitrust laws and the propensity of the shipping industry for collusion; the actions taken by shipping cartels are illegal in many modern economies. However, it is worth studying illegal behavior because it tells us what firms will do if unconstrained, and thus contributes to our positive understanding of firm behavior.[1]

[1] On the policy side, if predatory pricing does not exist, then we do not need laws forbidding it and we could save the resources used in enforcement. If we see undesirable behavior, then understanding what features of the environment and competition the behavior depends on helps us form relevant policy prescriptions.

The results reported in the paper confirm that entrant shipping line characteristics help predict the probability of a price war: a very young firm is a weaker entrant and is more likely to be preyed upon. The young firms in the dataset are "weak" in the sense that they lack financial resources, have little multimarket contact with rivals, lack experience, and lack an established customer base. I find no evidence that long term contracts for cargo or government subsidies are important in determining the strength of an entrant. Nor do I find that the amount of time since the last war occurred is relevant to the probability of predation, which might be the case if the incumbents were trying to maintain a reputation for preying. I do find that contracts and government subsidies affect the share with which the entrant enters, however. The significance of some entrant-specific characteristics in determining the incidence of war lends support to theoretical models with the same feature. The results provide the most support for the "long purse" theory of predation. An additional note is that the age of an entrant is unrelated to the state of competition, demand, or supply shocks,. This finding provides support for the idea that the price wars were not simply the outcome of vigorous competition in the context of demand and supply shocks.

The organization of the paper is as follows. In Section 2 I discuss the predation literature and the way these models could fit the behavior of shipping cartels. Section 3 sets out the qualitative evidence for predatory pricing, industry characteristics, practices, and intent.[2] Section 4 outlines the model while Section 5 explains the variables used in the estimation and discusses the results. Section 6 concludes.

2. Predation Literature

The amount of theoretical literature in the predation area is vast. The position of the Chicago School provides a valuable null hypothesis and starting point.[3] A firm will not engage in predatory pricing because it would have to be able to recoup its short run losses by earning excess profits in the long run. Those future profits depend on its successfully driving out the entrant or rival and then maintaining monopoly power long enough to earn back its lost profit, which is difficult in a free market. The problem becomes even more difficult should a cartel, rather than a single firm, consider predation. The distribution of losses and gains must be arranged, and free-rider cheating must be controlled. The proponents of this view conclude that price wars are not evidence of

[2] The historical details of the three cartels I use in my dataset and a rough picture of shipping firm finances are covered in Appendices II and III.

[3] For example, Bork (1978).

predation, but evidence of competition. Perhaps cost changes or demand shocks trigger the periods of low prices, but the intent is not predatory.[4] [5]

In a summary of the recent literature, Ordover and Saloner (1989) list three reasons a firm might undertake predatory pricing. The first is asymmetrical finances, or the long purse story, where war begins because each side believes it has the greater financial resources. If the incumbent's superiority were common knowledge, entry would not be an equilibrium strategy for the entrant. Some versions of the theory depend on imperfect capital markets.

Signaling (asymmetric information) is a second explanation of predatory price wars. Ordover and Saloner compare signaling to standard limit pricing, except that the entrant has already entered. Predation will occur in cases where the entrant lacks information about demand or costs. For example, in Fudenberg and Tirole (1986), predation is used when it the entrant is less informed or weaker, and can be convinced to exit. A price war might lower acquisition price (McGee 1980) or, by analogy, convince the entrant to accept a lower number of sailings (market share) in the final agreement. Saloner (1987) notes that the incumbent is trying both to induce exit and to improve its own position in case the entrant actually stays.

Creation and defense of a reputation is the third story behind predatory pricing. Selten's chain store paradox (1978) shows that predatory pricing in the face of entry is irrational in a finite game. Milgrom and Roberts (1982) look at reputation and its importance in the case of uncertainty. They prove that when potential entrants can enter every period, the incumbent's reputation for preying will have a deterrent effect on entry and therefore some initial predation may be rational. Their result depends on a finite horizon for the game, which is not the case in most industries, including shipping. However, Fudenberg and Levine (1989) show that in the case of an infinite horizon, a monopolist committed to a strategy can get at least his Stackelberg equilibrium payoff if he is sufficiently patient. Preying to convince entrants of its strategy can be profitable for a monopolist in a game that does not end with certainty in any period.[6]

Two General Types of Predation Models

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[4] For example, Slade (1989) and Green and Porter (1984) describe models where demand shocks cause a price war to begin among colluding oligopolists.

[5] A phenomenon which may be related to the cartels' existence and pricing patterns is that of the "empty core." Considerable scholarship has applied the theory of the core to the problem of ocean shipping e.g. W. Sjostrom (1992) and S.J. Pirrong (1992). Although the empty core may well have contributed to cartel formation, the question still remains whether the cartel fought entrants or whether periods of low prices represented spells where equilibrium did not exist. The question of why cartels fought price wars can be addressed regardless of the motivation for cartel formation.

[6] Indeed, the incumbent can to do better than Stackelberg, if it is faced with forward-looking entrants, by committing to a strategy over time.

There are two main types of predation models. Those such as Milgrom and Roberts (1982) or McGee (1980) derive very strict results; predation is rational but never necessary, or useless and never used. In contrast, other models predict predatory behavior will be less common or less often optimal when the entrant has better "survivability" characteristics, or is "tougher." These papers allow for an entrant's characteristics to affect the chance of a price war. Whether the entrant's toughness is a long purse or an investment of some kind, the general conclusion we can draw from this strand of the literature is that predation is less likely to be undertaken against firms which are stronger. If this sort of model corresponds to the shipping market of the late 1800s, then entrant and market characteristics should help explain the probability of a price war.

For example, Fudenberg and Tirole (1985) propose a theoretical model for the traditional 'long purse' story. In their model, predation causes the entrant to have sufficiently little cash after entry that it cannot stay in the market; no bank will lend to it at a profitable interest rate. An entrant with more cash, or a better relationship with its bank will attract less predation. In an extension of the Fudenberg and Tirole model, Snyder (1993) shows that long term contracts between an entrant and its bank can succeed as a predation defense in some cases. The long term nature of the financing strengthens the entrant. Bolton and Scharfstein (1990) examine yet another 'long purse' type of case. Suppose a firm is financially constrained in order to provide managers with incentives, then its rivals have a motive for attempting to make the firm earn losses in a price war and exit. The price war will only be successful if the entrant is sufficiently weak that the incumbents can force exit. The type of model which allows for different outcomes depending on entrant and market characteristics motivates the empirical work that follows. I test if variables of this type help predict the probability of a price war.

Unfortunately, empirical studies of predatory pricing are rare due to a lack of suitable data; predatory pricing is often illegal in modern economies. Evidence of predation has been found in empirical work, mostly historical, such as Burns' (1986) study of American Tobacco preying to reduce the costs of acquiring rivals. Weiman and Levin (1994) show that Southern Bell Telephone priced below cost and earned drastically less per phone in areas where it competed with rival networks; the company succeeded in driving out or merging with most of its rivals by 1913. Genesove and Mullin (1996) show that the Sugar Trust priced below cost in the late 1800s and argue that the Trust was trying to drive out recent entrants. Lerner (1994) finds evidence for long purse predation in the disk drive industry. He finds that healthy firms choose a lower price for products located in product space next to products of financially constrained firms in order to drive out those weak firms. This set of studies provides evidence that predation is a viable strategy for a firm.

The legal standard for identifying predatory pricing involves examining the relationship of the low (possibly predatory) price to different measures of costs.[7] Since I do not have detailed costs over time, much less marginal cost data, it will be impossible for me to prove predatory pricing existed according to common legal standards. Moreover, as economists we are not especially interested in the legal standard. The definition of a "predatory" price which I will use throughout the paper is a price which is lower than it otherwise would be due to an intent to force exit of a rival.

3. The Merchant Shipping Industry

Merchant shipping has the classic features of scheduled transportation industries. Airlines, shipping, and railroads all feature large fixed costs of running the trains, planes, or boats. The transport system commits to a regular schedule of departures and stops at intermediate destinations no matter how much cargo or people may want to use each particular stop. The marginal costs of scheduled transportation systems are very low up to capacity. Giving an additional passenger peanuts (plane), taking his or her ticket (train), or handling and storing a load of tea (merchant shipping) is not costly compared to the use of the capital. The cost structure gives providers an incentive to take on cargo at any rate above marginal cost if capacity is not full. This type of cost structure can lead to all kinds of interesting behavior -- price discrimination, price volatility, predatory pricing, for example -- because a low price can be charged that is not below marginal cost. Understanding behavior in the shipping industry will provide insights into the many other industries with similar cost structures.

3.1 Shipping Conferences

Shipping Conferences are associations of deep sea merchant or passenger shipping lines. British shipping lines invented the concept and the name "conference" which I will use interchangeably with "cartel." British lines were the largest, most technologically advanced, and dominant in most trade routes during the period.[8] Therefore, the first conferences could be

[7] Various standards for predatory prices have been advanced: price is less than marginal cost, short run marginal cost, long run marginal cost, average cost, or average variable cost, cost does not have any particular relationship to price due to more complex factors, and output increases. See Areeda, P. (1978) for full details.

[8] Additionally, British lines were privately held and did not receive large government subsidies, providing a better experiment for the economist. UK mail payments did exist, but on the routes in this dataset those payments were not designed to sustain a line when there was not enough private business to keep it going. In contrast, the German government subsidized several lines to Africa, explicitly noting that there was not enough business on the route for a line to run without government help.

composed entirely of British lines and nevertheless hold a monopoly position on a route.[9] It is important to note that the existence of formal cartels in the economic sense is not an assumption. It is possible to examine the actual contracts signed by the member firms agreeing to scheduling and freight rates, the freight rates agreed to, the sailing schedules agreed to, the dues paid, and the correspondence written by members of many conferences.[10] In addition, there are scores of secondary sources (listed in the Bibliography under "Data Sources") which report and comment on the behavior of the conferences because they were financially and technologically important.

A Shipping Conference is composed of a number of lines, all traveling the same route.[11] A shipping line (or firm) might have been quite small, three ships for example, or could have been large enough to cover many routes all over the world, as many of the well-known shipping firms did. The purpose of a shipping conference was to set rates and sailing schedules to which each line would adhere. The cartel also allocated market shares of specific types of goods and decided the exact ports to be served by each member line (which had a similar effect since production of a good was often concentrated in one area).

A conference agreement includes all shipping lines providing scheduled service on the route. Part of the definition of a conference is that is has a complete monopoly of scheduled service (hence the conflict when another firm wished to offer service on the route). Conference size in my dataset ranges from five to fifteen or so members. Two of three conferences studied here cover routes from the UK to British colonies (UK to South Africa, UK to India), the third runs from the UK to the Far East (China, Japan, Hong Kong); all are mostly composed of British firms. See Appendix II for more detailed histories of the conferences.

Cargo rates were rather like modern day airline fares. Each type of good had a different rate, often nonlinear in quantity, as did each port-pair. Some large shippers had long term contracts which offered savings off the standard rates. On top of that, some shippers might be able to claim an additional rebate (discussed below). As a result, it is nearly impossible for a researcher to construct an average per ton rate for even one month on one route; I do not attempt it in this paper. Additionally, there are no price series which hold these factors constant over a significant time period, so the paper does not contain an analysis of price movements over time such as Green and Porter (1984).

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[9] The first conferences were formed in the 1870's; the practice quickly spread and has lasted to the present day. By the turn of the century most shipping routes had a been cartelized, although many of these cartels were not stable.

[10] The Shipping Records Archive of Glasgow University, Scotland, is one such repository.

[11] Technically, each conference agreement would apply to only one direction of one route, UK to Calcutta for example, because the opposite direction might be served by a different set of firms. Boats often travelled circular routes, A to B to C to A, for example. A line running a ship from A to B would belong to the A to B conference, but not to the conference on the B to A route. I include both directions of the route in my discussion and analysis because my three conferences had a high proportion of overlapping members in the two directions.

3.2 Qualitative Evidence Concerning Predation

As mentioned above, there are a plethora of secondary sources on the early shipping industry. Shipping was very important to the political economy of Britain in the late nineteenth century; it helped the nation retain control of its colonies and fed the industrial revolution with raw materials and export markets. The popular press, the business press, and the government wrote about to the activities of British shipping lines and the conferences they belonged to. The three conferences used in this analysis cover politically important trade routes (South Africa, India, Far East), and remained intact and stable for the whole period, which improves the amount of available evidence. Both the qualitative and quantitative data I use in this study were collected from firm histories of shipping companies, general histories of shipping, or histories of a specific port which were generated due to this popular interest.[12] Most of these books are not specifically about the operations of a particular cartel and the entry it faced, and therefore tabulating and cross-checking the data was a difficult and time-consuming process. I also had access to some primary sources: correspondence, ledgers of accounts, and contracts written by the members of some cartels, as well as the minutes of a government investigation into (allegedly destructive to colonial development) conference practices. All the descriptions of market practices and the characteristics of conferences which affect the success of predation are culled from these sources. Because the quantitative information I have is limited, it is important to have the support of qualitative evidence, and therefore it is presented in some detail below.

The qualitative evidence on price movements (not available for many cases of entry) challenges the explanation of the Chicago School because prices seem to not always move with supply and demand. Suppose entry causes prices to drop because supply has increased, and exit causes prices to rise for the same reason. In some of the observed cases of entry, market prices rose a few weeks after they plummeted due to entry, but no exit had occurred. Prices are described as changing dramatically from one week to the next, more rapidly than demand could have changed, without corresponding changes in capacity. Also, price levels are correlated with membership in the formal conference organization; prices rise from price war levels to exactly the pre-war level at the time the entrant is admitted to the formal conference organization. At the same time, the secondary sources quote a letter or newspaper report saying that the entrant has agreed to abide by the conference prices and has been assigned a market share. This combination of events is more consistent with a deliberate price war than the interaction of supply and demand. To determine sound cases of predatory pricing, Easterbrook (1981) suggests finding evidence of firms being driven out of the market by low prices and *then* of prices rising. Table I lists several

[12] These sources are listed at the end of the paper.

cases of entry where prices fell and then rose in cases where the entrant was driven out as well as those where the entrant joined the cartel.

Establishing predatory intent is an important part of the qualitative argument. Appendix I quotes from a series of letters between members of a conference facing a determined entrant. The members discuss "punishing Strick by making him take unremunerative rates" and "repel[ing] his attack" because there is "no room for the Strick Lines" in the trade. The lower prices they agree to charge in these letters are a deliberate and conscious attempt to force Strick to leave the market. One of the cartel's problems that leaps out at the reader is the difficulty of coordinating the competitive response to an entrant. The burden of fighting the entrant will likely fall unequally on members as will the cost of admitting the entrant. Cartel members reduced conflict by using direct transfer payments among themselves; these are described frequently in the secondary sources and must have been very common. In this way any Pareto improvement could be taken advantage of.

The strength of a conference's market power is critical in deciding whether predation could be a profitable strategy. The only substitutes available to the merchant were sailing ships (speed depended on the weather), tramp ships, or a specially chartered vessel. The distinction between a liner and a tramp depends on how the ship is scheduled. A tramp picks up a full shipload of cargo X at port A and carries it to port B, whereupon the ship looks for another contract. Tramps operate on a spot market where rates may fluctuate overnight according to supply and demand. Tramps were a viable option in a port such as Singapore where many ships passed through on their return journey to Europe with empty space.[13] In South Africa tramps were rarer and did not reliably have space at any given time. In all the conferences, speed was probably the most crucial distinguishing characteristic of the conference ships. Relatively valuable manufactures and tea had high opportunity costs of time. Therefore, slower means of transportation were not very good substitutes. Additionally, chartering a slower tramp required paying for the whole ship. The chartering solution would not be feasible for a merchant who wanted to send regular, less-than-shipload lots; too much space, capital, and risk was involved. The data sources I read never describe a merchant resorting to tramp shipping due to the high prices charged by conference ships. Additionally, the conference defended itself vigorously against charter companies; those merchants who joined together to form a charter company would be discriminated against by the conference during their rebellion and perhaps afterwards also.

There is some evidence that prices in all three conferences generated positive profits for cartel members. During price wars, the entrant line was occasionally able to operate without loss at the

[13] In fact, the "Straits Conference" from Singapore was very unstable and much less successful than others due to tramp competition

"fighting" rates. For example, Solomon (1982) reports that during the price war caused by the entry of shipowner Houston in the South African trade, Houston's half-price rates were enough to cover his costs and the costs of the slower Conference lines.[14] Letters from the owner-manager of the Blue Funnel line report that Far East Conference rates increased Blue Funnel earnings by 20% over free market rates.[15] The Calcutta Conference members claimed to be earning profits after cutting their prices in response to entry by India Mutual.

If excess profits were being earned, then the conference had to be concerned with protecting its monopoly position from firms that wanted to share in those profits. Besides fixing rates of freight and volumes carried, the conferences invented the "deferred rebate" which may have accomplished this. To promote shipper loyalty, the lines arranged to pay back a certain percentage (usually 10%) of a shipper's total freight bill over six months, *if* the shipper had patronized the conference exclusively during that six months and for a further six or nine month waiting period. Therefore the shipper faced the loss of 10% of a year's freight if he decided to switch his business to an entrant. The deferred rebate created a strong barrier to entry, which, as noted above, is necessary for predation to be profitable.[16]

If the cartel could protect itself from external challenges, it still faced the common problem of cartel members themselves cheating on the agreement. A convenient feature of shipping from a collusive point of view is that it is impossible to expand capacity (number of ships) without being detected. Secret price discounts for major customers was the only feasible way to cheat, but keeping discounts secret was difficult due to the fact that brokers were involved in each transaction. Brokers were the equivalent of modern-day travel agents. They made reservations for freight and collected charges from the customer. Brokers often worked for more than one shipping firm and had their own reputations to maintain. The histories I have read suggest that cheating on the part of cartel members was not a significant problem

Revenue pooling also cut down on the incentive to attract cargo away from other lines and promoted stability by giving the aggressive line only a fraction of marginal freight revenues. A revenue pool might require every line to contribute 50%[17] of its freight revenues, for example, to a common fund. Distributions from the fund were made in accordance with previously agreed upon market shares. Revenue pools, direct payments, and cargo sharing agreements developed in

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[14] F. Solomon (1982). "Slower" ships were older and less expensive to purchase.

[15] Hyde, F. (1967) p96.

[16] Shipping conferences have been accused of creating the deferred rebate to protect their monopoly for many years. Traditionally, they have defended themselves with various reasons why the deferred rebate is necessary, but not anticompetitive. For example, the penalty could have been designed to promote stablility in the amount of cargo shipped, which would lower average costs by allowing the shipowner to match demand and capacity exactly.

[17] a typical level

all three conferences. Additionally, the British Government made shipping lines bid for long term contracts to carry its cargo; government cargo was usually exempted from a cartel agreement. A cartel therefore did not enforce any agreement for the segment of the market where collusion might have been harder to sustain.[18]

Predation requires imperfect information or imperfect capital markets; otherwise it is not a rational strategy. The capital markets of nineteenth century Britain were certainly not primitive, as the quotation below indicates, but it would be difficult to argue there were no imperfections.

> "The boom in the market for stocks and shares of all kinds after the repeal of the Bubble Act in 1825 included massive joint-stock promotions in the shipping industry...The new capital was sorely needed...to cover the much higher costs of iron-hulled steam-powered fleets...and no less than 413 shipping companies were registered under the new limited-liability legislation between 1856 and 1881. The more extensive use of limited liability in the 1890s and early 1900s improved owners' opportunities for introducing external finance."[19]

Limited liability allowed the owners to use external financing more easily. However, Green finds that ship owners had not been eager to borrow from banks in the early part of the period.

> "For most of the nineteenth century the industry had been reluctant to ask banks and other institutions for support...'it was never company policy to attempt to secure outside finance.' For their part banks had been unenthusiastic about closer involvement."[20]

A reliance on private financing would increase the informational asymmetries required for a "long purse" price war. Incomplete information regarding financial resources was a characteristic of the shipping industry in this time period. Most shipping firms were privately owned. Their capital would typically be owned by one or two extended families and neighbors. Each firm would have a different mixture of loans and equity, and partners with different wealth and liquidities. Thus a cartel would not have known the exact financial strength of an entrant nor would an entrant know the precise financial strength, cohesion, or prospects for growth of a cartel.

Price wars were exciting events for the media of the day, uncommon enough to be news, but common enough to be analyzed for motives and patterns. The dataset I have constructed has 47 cases of entry of which 14 are price wars. Based on a lot of reading from the industry and time period, this proportion of wars does not seem unusual. Overall, liner shipping in this period was

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[18] Bargaining over prices was common and provided more information about cheating. A large customer would typically claim that the goods were not selling at their destination due to high transportation costs. The cartel would consider whether or not to lower the freight rate on that product. The customer would end up paying the cartel rate or not sending the goods. If the customer instead used a rival line, (rather than the geographically closer line or previous provider) the cartel would have a strong hint that the new carrier had cheated on price.

[19] Green, "Ownership" p229.

[20] Green, "Ownership" p230.

uniquely placed to try coordinated acts of predatory pricing. Predation was not illegal, ships were fungible, marginal costs were low, transfer payments within the cartel were easy, and the deferred rebate created a barrier to entry. All of these factors contributed to creating a favorable environment for predation activity.

4. Model

Most predation is modeled as occurring due to private information, but I cannot use that technique here. If a party has private information, it may think it will gain from either entering the market or starting the price war. *Ex post*, one economic agent discovers its action was a "mistake" and would not have undertaken the entry or war if it had had full information. Any characteristics of the entrant which were common knowledge and therefore available to the econometrician should, therefore, not predict predation.[21] What *should* predict predation is private information available to either party. However, neither the cartel nor the econometrician can use private information in a regression, for example, so another type of model is needed for this study.

Suppose the entrant line has a type, t, which represents its strength in terms of cash and other resources.

$$t = X\beta + \varepsilon$$

ε, and therefore t, are unknown to any party, while $X\beta$ is common knowledge. If there were no uncertainty about an entrant's type, strong entrants would enter and weak ones would not. We would never observe price wars. ε is therefore crucial; its distribution is described by cdf F(.) and pdf f(.). The cost of fighting a price war to the entrant is c, where $c>0$. The cost of fighting the war to the incumbent cartel depends positively on the strength of the entrant and is $C(t)>0$. For convenience, the entrant's outside opportunity will be zero. If the entrant is accepted into the incumbent cartel, its payoff is p and the cartel's payoff is -p. One way to think about the magnitude of p is that it represents a share of cartel profits forever, $\Pi/(rn)$, where Π is cartel profits, r is the discount rate, and 1/n is the market share allotted to the new entrant. The extensive form game is as follows:

[21] In this study, the information available to the econometrician would have been common knowledge to other shippers *ex ante* (as the entrant entered) as well as *ex post*.

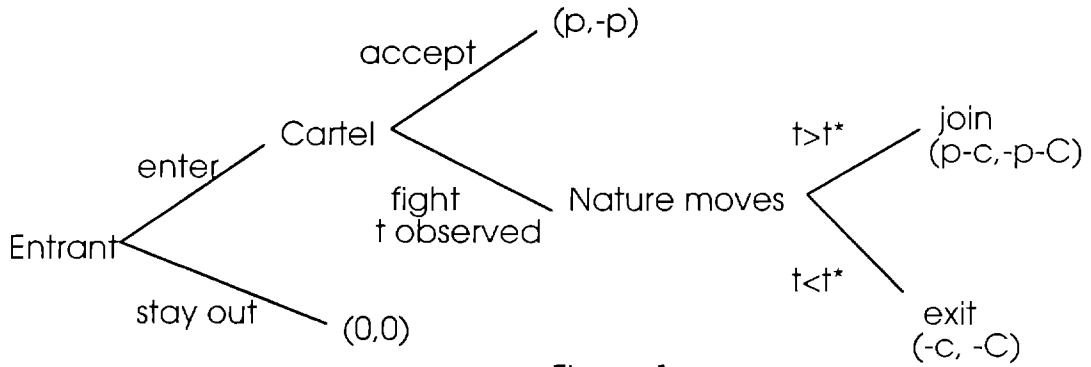

Figure 1

t* is defined to be the (known) entrant strength at which the cartel is indifferent between forcing exit and admitting the entrant. Define $\pi=\Pi/(m)$ and define $\underline{X\beta}$ by,

$$pr(\underline{X\beta}+\varepsilon > t^{*}) \cdot \pi - c = 0$$

and define $\overline{X\beta}$ by,

$$(1-pr(\overline{X\beta}+\varepsilon > t^{*})) \cdot \pi - E[C(t|\overline{X\beta})] = 0$$

The entrant prefers to enter if: $\underline{X\beta} \le X\beta \le \overline{X\beta}$ and $pr(t > t^{*}|X\beta)\cdot\pi - c \ge 0$

The cartel wants to fight the entrant when, $X\beta \le \overline{X\beta}$ and $pr(t < t^{*}|X\beta)\cdot\pi - E[C(t|X\beta)] \ge 0$

Should a price war actually occur the cartel's decision rule is to admit the entrant if its type turns out to be greater than t*, but to drive it out otherwise. The strategies can be expressed more succinctly in the following diagram.

no entry		war		no war/admit
t <----------	| ----------	| ----------	| ----------	> t
	$\underline{X\beta}$ force exit	t^{*}	admit	$X\beta$

The interesting region here is the middle one, where the entrant knows it will be preyed upon and yet enters anyway. Assume in this region that π - c - C(t) > 0; this is equivalent to saying that the profits at stake are large compared to the cost of predation for some part of the distribution of potential entrants. I believe this is a realistic assumption for my data. The assumption is necessary to show that the intermediate region exists.

If $\overline{X\beta} \leq \underline{X\beta}$, then

$pr(\overline{X\beta} + \varepsilon > t^*) \cdot \pi - c \leq 0$ and

$(1 - pr(\overline{X\beta} + \varepsilon > t^*)) \cdot \pi - E[C(t|\overline{X\beta})] = 0$

summing, $\pi - c - C(t) \leq 0$, a contradiction

The intuition for the game is straightforward. An entrant with cash and other resources is more expensive to fight. The cartel would prefer not to share the market with any entrants; it calculates the cost of forcing an entrant to exit and compares that to the gain (recovering profits) from exit. In some cases the common knowledge characteristics of the entrant make this calculation come out strongly one way or the other. In other cases, it is not clear how many resources the entrant has (its type). In this case, it is worth fighting the entrant to learn its type because the probability of winning times the profit recovered is greater than the expected cost of the war. The value of ε and the entrant's true strength is revealed to everyone in the event of a price war due to the strain of the war on the entrant's resources.

I have a set of measurable entrant characteristics, X, that can be used to estimate the entrant's true type. Regressing these characteristics on whether or not a price war occurred will generate two interesting results. First, if any of the characteristics are statistically significant then the private information model, more common in the literature, is not completely appropriate for shipping cartels. Secondly, the coefficients on the variables will provide estimates of which characteristics give the entrant significant strength. From the above equilibrium strategies, the appropriate equation to estimate is,

$$\Pr(\text{War} \mid \text{Entry}) = \Phi(X\beta + \varepsilon).$$

5. Variables and Estimation

5.1 Variables

I include in the dataset when, where, and for how long price wars occurred; these facts were consistently reported in the texts just mentioned. Facts such as the pattern of price changes around the entry event are usually not described, unfortunately. Most of the entry incidents are mentioned in more than one source, so I am quite confident that events occurred as reported. I record a war, rather than entry without war, when the historical sources describe a sharp commercial conflict between the parties including price cuts. Sometimes the texts use the term "price war" when describing vigorous price decreases in the history of the firm or market, but not

always. Other common descriptions are "sharp price decrease," or "rates dropped by 40%," for example. If entry involves only negotiation and no price cuts, or minor price changes (five or ten percent) then it is not classified as a war.[22] A typical price war might last three months and feature a price drop of fifty percent to the ports the entrant has chosen to serve. Price decreases of greater than fifty percent are also observed, as well as wars that lasted as little as two days or as long as one year. Four potential observations were dropped due to insufficient information on the tonnage of the entrant or whether or not it was receiving a government subsidy. There were an additional five or so references to price wars in secondary sources that did not identify either the participants, the time period, or the market, so I was unable to use them as observations. I have no reason to believe that the omitted observations vary in a systematic way from the included observations, but there is no way to know for sure.

Clearly shipping conferences felt that keeping their monopoly positions was worth periodic price wars. However, they did not fight every entrant which threatened to erode the conference's monopoly position. A price war is an expensive way to protect a monopoly. The first concern of any type of entrant or cartel would be the cost of fighting a price war weighed against the benefits. It is impossible to determine the expected cost of a war without detailed information on marginal cost for each ship in each line, composition of cargoes, exact structure of rate cuts, etc.[23] However, it is possible to find some proxies for the cost of a price war. Below I describe each explanatory variable and its possible impact on the cost of a war as well as the predation theory it supports.

Testing the long purse hypothesis requires data on the financial backing of an entrant: personal resources of the main owner and his[24] family, resources of other equity holders, relationship with bank, and outstanding loans. Much of this information is unobservable to me, so I must use proxies.[25] *Firm Tons* is the total number of ten thousands of gross tons of shipping that the

[22] I chose a cutoff point of 20%; price decreases greater than this counted as wars, otherwise the incident was not a war. The distinction was made easy because there is a natural break in the data around this point; all reported percentages were either small or more than 30%.

[23] If the entrant were serving a selected port or carrying a particular commodity, the price cuts could be specifically targeted and the cost to the conference members much reduced. The war against DADG's entry to a single South African port in 1894 is a perfect example; the conference lowered rates on fertilizer and machinery to that port. Often I can't find this information for an observation, and other times a general price cut was required.

[24] All shipowners during this period were men.

[25] However, I do know whether the company was publicly traded on the London Stock Exchange or not and can use that as an explanatory variable. Stock Exchange Intelligence lists publicly traded shipping companies' financial structure in its yearly report. The long purse hypothesis is less likely to be a motivation when the entrant's financial situation is publicly known: a public firm can conceal less information than a privately owned firm. However, most of my entrants were not publicly traded and I found the dummy variable, *Publicly Owned*, empirically ineffective, so it is not discussed further.

entrant owns; all of them may not be on the route in question. The tonnage data come from the annual publication Lloyd's Register of Shipping. During this time period, Lloyd's reported the tonnage, type, and owner of every ship in the world, allowing a researcher to construct a tonnage series for each shipping line for each year which is very accurate. The data sources make clear that the size of the entrant firm is correlated with financial and other resources. The very biggest lines had large cash reserves and networks of ships all over the world. The larger the firm, the more likely the price war was occurring on only part of its routes and the more cash the firm would have had. Also, a firm operating on more routes raised the likelihood of multimarket contact with a firm in the cartel. For these reasons, a very large firm would be less likely to provoke a price war after entering a given route. A Fudenberg and Tirole long purse model fits here, as well as a standard cost-benefit tradeoff as entrant strength increases.

I also know the number of gross tons the entrant places on the route (*Route Tons*) from secondary source descriptions of the entry incident.[26] The amount of tonnage the entrant places on the route determines the maximum volume of trade the cartel loses. As the size of the successful entrant rises, either *ex post* Cournot prices (including the new entrant's capacity) will fall or else current members' share of perfect monopoly profits will fall. Greater lost profits from large entrants lowers the opportunity cost of any type of price war.[27] As the entrant's tonnage on the route (*Route Tons*) increases, it is likely to provoke price wars; the cartel would like to drive down the entrant's route tonnage even if it does not expect to drive it to zero. A line's *Firm Tons* are not relevant to this problem.

The dummy variable *New* is assigned a one if the firm had existed for less than five years at the time of entry. A young firm is unlikely to have the cash and insurance reserves common to established shipping firms at the time.[28] When a firm was founded, funds were used to purchase ships and begin operations; large amounts of cash were not set aside. After a firm had been in existence for a while, it would have built up cash reserves and it might be self-insuring, in which case it would have additional cash reserves. Since most shipping firms were privately held, the data do not reveal what the cash positions of each firm in the sample were at each entry date. I assume that the conference is more likely to think its own reserves were greater than those of the

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[26] I realize that net tons would be a better measure of capacity than gross tons (Net tons measures only cargo space whereas gross tons includes the space taken up by the engine and fuel). However, gross tonnage data were available for all observations while net tonnage data were not.

[27] An alternative explanation for price wars could be irrational behavior on the part of either incumbent or entrant owners. It could be the case that friendships, connections, and pride were stronger motivations for shipowners than profits. It is also possible that outside shareholder control was more difficult during this period, leading to less monitoring of managers and their profit-maximizing behavior or lack thereof.

[28] This statement says nothing about the financial positions of the *owners* of the firm, as opposed to the firm itself.

new entrant if the entrant is a "new" firm. If a difference in expectations exists it would generate a long purse argument for predation.

I believe that there is not a significant skill and information differential between old and new firms. Most "new" entrants in the dataset are run by managers with a great deal of experience in the shipping business. Typically, a manager with ten years of management experience at a shipping firm borrows money from his relatives and starts out on his own. These managers have a lot of experience with the trade and good information about the market. For example, I find the difference in the growth of trade in years when new entrants entered compared to years when other entrants entered is not significant. The value of *Firm Tons* differs significantly between *New* and older entrants (100 compared to 28 thousand tons, t-test 2.09) as one might expect. However, *Firm Tons* is included separately in the regression, as described above. The value of *Route Tons* does not differ significantly between the two groups.

Contracts secured by an entrant before entry will make a long purse price war less effective, therefore longer and more costly to the conference and in turn, less likely to be undertaken. *Contract* is a dummy variable taking a one if the entrant has a long term contract for cargo on the route. This information is taken from the entry description in the secondary sources. *Contract* will capture the Snyder version of the long purse theory. Long term contracts should have reduced the likelihood of all types of price wars by increasing their cost; the entrant had to maintain sufficient tonnage to fulfill the contract and that tonnage would be immune from a price war.

Trying to make a government subsidized line (*Government Subsidy*) run out of funds and exit does not make much sense since the firm has a softer budget constraint. However, a war against a subsidized line could be effective in convincing it to reduce its services on the route.[29] Government-owned firms are not run by owners, in contrast to most of the firms in the sample, but by professional managers. A Bolton-Scharfstein long purse hypothesis where the cash problems due to the price war pressures managers might be the correct model. The coefficient on the dummy variable *Government Subsidy* will indicate whether a subsidized firm is more or less likely to be preyed upon for long purse reasons.

The entrant's opportunity cost, which here is relative trade growth on other routes, will affect incentives to enter and exit which in turn affect the incidence of price wars. *Outside*

[29] Both German and Japanese subsidized lines experienced problems gathering and keeping political support for their subsidies, especially when they made losses. Non-monetary as well as monetary penalties existed for managers of publicly-subsidized firms which earned persistent operating deficits: the line could be closed down, or the management altered. NYK had an unstable political constituency in the Diet in the 1880s; its subsidies were approved with difficulty and the debate affected its status in the conference. NDL lost 5.25 million Marks on mail steamer lines to East Asia and Australia despite a subsidy of 44 million Marks. Scholl (1985) p200.

Opportunities is defined to be a two-year moving average of the growth rate of all British trade excluding the entrant's route less the growth rate of the entrant's route.[30] A change in alternative trade conditions affects the entry choices of potential entrants.[31] In particular, if outside opportunities get worse, weaker entrants will find it worthwhile to attempt entry into the cartel. In that case, a higher equilibrium level of predation on the part of the cartel may be optimal. A decline in *Outside Opportunities* could therefore increase the probability of a price war.

Trade Growth is a two-year moving average of the percent change in the value of trade on the route. The value of *Trade Growth* fluctuates widely from year to year because of extremely procyclical trade flows during the late 1800s. If trade on a route was increasing the conference may have been less likely to fight a price war; a price war would mean more foregone profits than a war during a recession. Additionally, a trade boom (*Trade Growth*) reduces the need to bargain down the entrant's quantity in absolute terms. Although the cartel should have valued additional boom trade as much as current trade, the difficulty of coordination within the conferences caused heavy reliance on the *status quo*. It was much easier for a conference to allocate six sailings a year to an entrant if the original members could keep their current schedules. Arguing over which lines would make room for an entrant in a case where the market was not expanding was a time consuming, tension-filled, and costly process. Hence, increasing trade on a route made negotiating entry easier. This variable picks up the cost of a price war, rather than testing one of the three theories.

Time Since Last War is a dynamic variable measuring the number of years since the last war occurred in the cartel. (This variable is not defined for the first entrants in each cartel.) If there has not been a war in the conference for many years, the members will have more cash reserves than if they have been fighting price wars recently, all else equal.[32] The variable *Time Since Last War* also helps explore reputation-motivated wars. If the cartel is signaling that it is a tough type with each price war and its reputation erodes, there will be less need for a reputation-building war if one just occurred. Therefore, the probability of war conditional on entry will increase as the last war recedes in time. However, if the cartel's reputation does not erode and is well-known before the sample period starts, this dynamic effect will not show up in the results. However, as mentioned above, *Time Since Last War* has cash flow implications which work in the same direction. *Time Since Last Entry* is defined analogously.

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[30] I use British Government trade statistics from the appropriate years to calculate all the trade variables.

[31] This variable is used for foreign entrants because they are sharing traffic on the trade route with the British incumbents, although they might not overlap 100% with business already handled by the incumbents. Also, industrial products originating in Germany (shipped by German lines) are direct substitutes for British products.

[32] Since trade is very cyclical, lines build up their cash reserves to outlast downturns and dispurse more money to shareholders when reserves are high enough (in the opinion of management). These cash reserves can be used to help a firm survive a price war also.

Throughout the study I consider the continental ports of Hamburg and Antwerp to be good substitutes for London, Liverpool, Glasgow, and Middlesbrough. A map of the area (Figure 2) shows how geographically close these ports are to each other, particularly in comparison to the long trade routes considered here. Additionally, Germany produced many of the same manufactured goods in demand in the Far East and South Africa, so transshipment of cargo was not necessarily required. German lines did enter all three cartels during the period and provided robust competition for the British lines.[33]

The information I have regarding entrants is sufficiently crude that one variable can feature in several hypotheses, especially if one imagines a few alternative models under that hypothesis. However, Table IV summarizes the expected effect on the probability of war for each of these variables under each strategic hypothesis.

5.2 Estimation

As mentioned above, the main specification I estimate is,

$$\text{Prob}(\text{War} \mid \text{Entry}) = \Phi(X\beta)$$

where the dependent variable is zero in case of an uncontested entry, one in case of a price war. The X's are the characteristics of the entrant and the market, which have been discussed previously.

The estimation of the probability of a price war is conditional on entry. An immediate reaction might be that there is a selection problem, and I should estimate an equation which explains if the line enters in the first place and then estimate an equation which determines the probability of war. However, the simplicity of the model removes this concern. The model assumes that an entrant can be characterized by one variable, strength. If the entrant is strong enough, it enters, and if it is strong enough again, it is not fought. So entry is already explicitly conditioned on strength in the model. For example, since strength is the only characteristic of interest, there does not exist an identifying variable (to use in a Heckman correction procedure) which affects entry and not the probability of war. The strength of an entrant determines both whether it will enter, and how successful it will be upon entry. An analysis of the entry decision would be very interesting study,

[33] There is a large literature on the topic of the growth of German shipping, its competition with British shipping and its success, and whether or not direct subsidies to German shipping lines during the period gave them an advantage over British firms. For example, see Aldcroft (1974).

but very difficult to undertake in this context since one cannot observe the set of potential entrants which do not enter.

5.3 Results

Results from the probit estimation are contained in Table V. The first specification in column (1) shows that firm and market characteristics are crucial in estimating the probability of war. *New* has a large positive coefficient; young firms are more likely to be fought by a cartel. A long purse theory could explain this result; *New* firms are less likely to have the accumulated resources that an older firm has.

Firm Tons has a negative and coefficient that is significant at the 10% level (one-tail test). It is of the expected sign; larger firms are stronger entrants and provoke wars less often. The effect is not constant across all firm sizes; the coefficient on very small firms is insignificant, but wars are less likely for firms in the second quartile. Between the second quartile dummy and the coefficient on *Firm Tons*, only the smallest firms have an un-reduced probability of predation. In total the entry of big lines is less often met with an aggressive response. A "long purse" explanation for price wars is consistent with the *Firm Tons* finding. On the surface this finding is inconsistent with Burns' (1986) result where he finds that American Tobacco preyed upon larger rivals, not smaller. However, there are several significant differences in the industries. First, capacity is fungible in shipping, so merging is not necessary to reduce competition. American Tobacco was much larger and stronger than all its rivals - unlike these shipping conferences - and we therefore never observe its response to a relatively "strong" rival. Burns claims American Tobacco picked fights with larger rivals because there was a larger merger premium available for reduction. The analogous statement for shipping conferences is that wars should have occurred against entrants that expanded capacity a lot; that could be the case here also if one believes the positive (but insignificant) coefficient on *Route Tons*.[34] The *Firm Tons* result is also consistent with multimarket contact reasons (cost) for avoiding a price war. On four occasions in the dataset, despite there being no price war, the entrant exited. In these cases, the lines reached agreements where each party would exit from the other party's "territory" to resolve the conflict created by the entry.

A larger number of *Route Tons* should do more damage to cartel profits; the opportunity cost to the cartel of starting a price war falls and the opportunities for renegotiation rise.[35] That story

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[34] I adjust the *Route Tons* variable by weighting it by the inverse of the route's distance; Indian observations remain unchanged. Since a longer route requires more tonnage to supply say, a monthly service, the adjustment facilitates route comparisons.

[35] See Gelman and Salop (1983) for a model where small entrant capacity reduces the likelihood of retaliation.

is neither supported nor disproved by the pattern in the *Route Tons* coefficients here. Each quartile of *RouteTons* was given its own coefficient so that the effect of entrant size could differ across sizes. Although the coefficients on *RouteTons* are nearly always positive - for all four quartiles and across specifications - they are never significant.

The extent of *Trade Growth* on the route negatively affects the probability of a price war. If trade is growing quickly, more profits are foregone in the event of war and the cartel is less likely to initiate one. Ceding market share to an entrant may also be easier to negotiate in the midst of a boom.[36] *Outside Opportunities* negatively affect the probability of a price war also. Booming trade on another route may reduce the incentive to enter and therefore the need for price wars. *Time* is significant if included; there is a small, positive trend in the probability of a price war over time. I expected the conference dummies to be significant; this could reflect different reputations or equilibrium levels of predation. However, the conference dummies are insignificant if included and the results for the other variables are unchanged; conference dummies are therefore omitted. The normal pdf evaluated at the estimated index is reported at the bottom of each column to allow calculation of marginal effects. The effect of *New*, for example, is quite strong; the probability of incurring a price war upon entry is about 36% higher for a young firm than an older one.

In column (2) I include two more variables that represent the strength of an entrant. Having a contract to carry cargo on the route (*Contract*) does not affect the probability of a price war; it was predicted to decrease the likelihood of a price war because the cartel realizes a war would be costly and ineffective. Likewise, having a *Government Subsidy* does not affect the probability of a price war. The two long purse effects of *Government Subsidy*, additional pressure on managers and the soft budget constraint, may be canceling each other out. These variables may also be too crude to pick up an effect; I do not have a great deal of historical information about these firms such as contract details and incentives or rules attached to subsidies.

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36 It is interesting to note that *Real Outside Opportunities* and *Real Trade Growth* are insignificant if they are included in the regression rather than the nominal values. The two series are quite different because a relatively small change in the general price level creates a large wedge between nominal and real rates of change. Only the nominal values have predictive power. Inflation and deflation were known phenomena by this period, but it seems unlikely that shipowners would deflate trade flows when thinking about how well a route was doing compared to last year. For example, Temin, P. (1987) reports that managers at AT&T analyzed nominal profits up until the 1970's. Alternatively, when managers deflated they may have used a price index specific to goods traded on that route and items that were part of costs; a specific price index of this nature might not have been very correlated with the overall consumer price index, which is what I have. Trade routes were often dominated by only a few products, e.g. tea or manufactured cotton products, for which I do not have price indices. In that case, the deflated trade measures are not reflecting anything economically significant and the variables should indeed be unimportant in the regression.

Column (3) adds a dynamic variable to the specification: *Time Since Last War*. The information about a cartel's behavior in the past might be helpful in predicting the current probability of war. It appears here that elapsed time since the last war in the cartel does not significantly increase the probability of the current entry triggering a war. This result gives no support to any dynamic story of learning or erosion of cartel reputation.

If the model previously discussed is correct, firms with lower types should not only be preyed upon, but on average they should exit more often. My estimation of the index for each observation is also the estimation of the firm's signal. I divide the 'war' observations into those that resulted in exit and those that did not; the first group has six observations and the second, eight. If the model is correct, we would see a higher index for the exit group than the accepted group. The two means from specification (1) are 0.622 and 0.349 respectively. However, because the sample sizes are so small, the two means are insignificantly different (t statistic=0.46). If the sample were larger, we would expect the exit group to have a significantly higher mean estimated index value.

Tables VIa and b report the outcomes of the price wars and focus on differences between the *New* and non-*New* groups. Of the war events, close to half resulted in exit by the recently-arrived entrant. It is clear from the raw event counts in Table VIb that New entrants face a much greater likelihood of both predation and exit. The fact that the predation is often successful supports the claim that cartels are more likely to prey on *New* entrants.

Despite a small number of observations, many of the coefficients from Table V are significant at the 10% level. Table VIc shows that the empirical estimation (column (1) of Table V) does quite a good job at predicting the outcome of entry. Ten out of fourteen wars are correctly predicted. The explanatory variables, characteristics of entrants and the market, are empirically important in determining whether or not a cartel will begin a price war. The significance of those characteristics shows that entry and predation decisions are not completely driven by private information. Additionally, the effect of age provides some evidence for a predatory explanation of price wars, rather than a demand or cost shock approach.

5.4 Correction for Misclassification of a Price War

It is possible that my sources may mistake a negative demand shock for a predatory price war. The reason this is of some concern is that if the dependent variable in a probit regression is misclassified, the resulting coefficients are biased (Hausman and Scott Morton (1994)).[37]

[37] Porter (1983) uses econometric techniques to identify railroad price wars and discovers a high correlation between his results and accounts of price wars cited by newspapers. His evidence suggests historical reports of price wars are quite accurate.

Misclassification could occur in the other direction also: an entry which resulted in a price war, but was never described as such in my sources. If a price war is misclassified then the estimates presented in Table V will be inconsistent. Hausman and Scott Morton (1994) discuss two methods for correcting such bias. One is simply to use a likelihood function which explicitly includes the possibility of misclassification, which we call α.[38]

$$pr(y=1) = pr(war|entry) = \alpha + (1-2\alpha)\cdot\Phi(X\beta)$$

Maximizing this likelihood function results in an estimate of the percentage of observations which are misclassified as well as estimates of the betas. The ability to identify the misclassification percentage comes from knowing the shape of the tails of the distribution. For example, as the value of the latent variable declines, the observed outcome still has an α percent chance of being a one due to misclassification. Because this method relies on the shape of the error distribution, I present results from a semiparametric method that does not depend on any error distribution. The semiparametric method has two parts. First I use Han's (1987) Maximum Rank Correlation (MRC) procedure to estimate the coefficients of the explanatory variables.[39] Secondly, I estimate the extent of misclassification with an Isotonic Regression (IR).[40] These techniques provide a basic check for misclassification problems and also provide a way to examine the assumption of normally distributed errors.

Table VII repeats the earlier probit results and gives both the MLE and MRC/IR coefficients. All of these methods estimate the ratio of the coefficients rather than their absolute size.[41] The MLE results which are robust to misclassification, but assume a normal error distribution, are in column two, and semiparametric results which are robust to both misclassification and non-normal error distribution are in column three. Column two indicates that some entries that are true "no war" entries may be misclassified as "war." The point estimate for the extent of this misclassification, α_0, is 5%, but the standard error is also 5%. The estimate of α_1, "war" misclassification, is zero, although it has a huge standard error because convergence was difficult

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[38] The idea behind this equation is that the probability of observing a one will be the probability that the latent variable *is* greater than zero times the probability that the outcome is not misclassified, plus the probability that the latent variable is *less* than zero but the outcome is misclassified. Writing down that expression and simplifying yields the likelihood function above.

[39] The observations are ordered by the index ($X\beta$) and then a sum is constructed by giving an indicator variable a "one" in cases where the dependent variables are also in the "correct" order.

[40] Isotonic regression non-parametrically estimates a cdf using ranked index values. The final estimate is in the form of a step function; the lowest and highest "steps" are the tails and provide consistent estimates of the misclassification percentages.

[41] MRC procedure estimates a normalized coefficient vector which must be rescaled by holding one variable fixed. *RouteTons if first quartile* is held fixed in Table V.

to achieve due to the small sample size. As expected, standard errors are higher than the probit standard errors because additional coefficients must be estimated. No estimated coefficient changes sign or magnitude between the two specifications; the same general conclusions can be drawn from the MLE results as the probit results.

However, the MLE results rely on the assumption of normally distributed errors, unlike the semiparametric results. The semiparametric coefficients lie for the most part near the original probit estimates, although the slope coefficient on *Firm Tons* increases in magnitude. The coefficients on the trade variables also increase by about fifty percent in magnitude. Notice that in contrast to MLE, the Isotonic Regression method estimates the first step at height zero and the last at height one; the estimates of both α_0 and α_1 are zero. According to these estimates, neither category of dependent variable suffers from misclassification.

Because the estimates in columns (1) and (3) are not identical, the assumption of normally distributed errors may not be a good approximation for these data. However, the robust semiparametric method produces results quite similar to the original probit results, so the normality assumption is not strongly affecting the coefficient estimates. The important conclusion of this section is that misclassification of the dependent variable does not appear to be a major problem in this dataset.

5.5 Estimating Entrants' Tonnage

The analysis thus far has focused on the entry decision as a zero/one choice. However, an entrant also had the choice of how much tonnage to place on a route when it entered. This choice should depend on firm and market characteristics, and perhaps also on the probability of predation. I examine a reduced form model of this problem to see if the results are consistent with the entry results already obtained. I look at that choice conditional on entry, thereby restricting the dependent variable to the strictly positive range. Potential entrants that placed zero tons on the route, i.e. did not enter, are not included. The equation I estimate is:

$$E(\textit{Route Tons} \mid \text{Entry}) = X\gamma + \varepsilon$$

where the X's are the characteristics of the entrants and the market discussed above with two additional variables. *Past War Percentage* is defined to be the cartel-specific percentage of entries which have resulted in wars up to the current entry. If a cartel's equilibrium strategy is to prey on a certain proportion of entrants to maintain a reputation and keep others out then *Past War Percentage* will be positively correlated with the probability of the current entrant attracting a war. A higher *Past War Percentage* may also encourage entrants to place more tonnage on the route since they are more likely to be bargained down in a price war. The second new variable,

Time Since Last Entry, is the number of years between the current entry incident and the most recent case of entry into the same cartel.

The results of an OLS regression explaining an entrant's route tonnage choice conditional on entry are reported in Table VIII. Relatively poor trade elsewhere (*Outside Opportunities*) causes an entrant to place more tons on the route. *New* has a large negative coefficient; young lines on average enter with a smaller amount of tonnage. Having a *Contract* causes a line to place more tonnage on the route, all else equal. *Contract* was not significant in the probit specification, but here displays a significant and positive effect on an entrant's tonnage. *Government Subsidy* is only marginally significant; firms receiving a subsidy may enter with more tonnage than otherwise.

The coefficient on *Firm Tons* supports rational behavior on the part of shipowners. The total amount of tonnage the firm owns (*Firm Tons*) has a very weak influence on how much tonnage it will place on the new route. Only if the upper bound is binding do we expect an effect. The coefficient on *New* perhaps represents the effect of imperfect capital markets. The coefficients of the conference dummies are determined by sailing conditions and magnitude of trade flows on the route and are not economically significant.

In column (2) I include *Time Since Last War* to see if it affects entrant tonnage. The coefficient is insignificant. If a cartel's reputation is well-known, then the amount of time since the last war should not affect the entrant's choice of *Route Tons*. This result is therefore not inconsistent with reputation theories, but is not evidence for them either. *Time Since Last Entry* might have a positive effect on entry tonnage because no other line has increased capacity lately. On the other hand, it might have a negative effect because trade conditions have been so bad no other line has *wanted* to enter. Thus, it is not a surprise that the coefficient is not significant in column (3). However, the proportion of entrants fought in the past is important. Column (4) shows that *Past War Percentage* has a large positive coefficient but it is not very significant either. Given that an entrant has decided to enter the route, it may want to enter with more tons if there is a history of price wars on the route. However, the coefficient drops in half if early entrants (*Past War Percentage* =0) are excluded from the regression. The result is being driven by early entrants who entered with fewer tons (perhaps because there was no history of organized opposition on the route or because technological change in ship sizes is not captured with the *Time* variable). The tonnage results are consistent with the entry results reported previously, but again, it is difficult to make any sense out of the dynamic variables because of the small sample and the complex setting.

6. Conclusions

The qualitative and quantitative results suggest that price wars in this industry were not caused by competition (demand or cost shocks), but by predatory behavior. If the wars occurred simply because of market conditions, then the variable *New* should not be significant. The age of an entrant line should be irrelevant to the opportunity cost of entering or exiting the route and the size of any supply or demand shock. Young entrants do not differ from older entrants on the basis of characteristics in the dataset. However, if the two groups differ systematically in some way I cannot observe, then age might be picking up demand or supply shocks. The intent expressed in the correspondence between members of the cartels as well as other anticompetitive behavior exhibited by the cartels provides additional evidence for the predation story.

The results of the analysis here suggest that British shipping conferences engaged predatory price wars, and the incidence of such wars depended in part on the characteristics of the entrant and the market. Opportunities for outside trade, growth of trade on the route, the age of the entrant, and the size of the entrant's firm all contributed to the cartel's decision to prey. The overall results provide support for the general type of theoretical work which argues predation will be a more profitable strategy against "weaker" entrants. The characteristics which I find make an entrant weak are lack of age, or lack of the experience and financial resources correlated with age, as well as weak market conditions. Larger absolute size of the firm, regardless of its entry size, also makes the entrant stronger. This result is most consistent with the long purse theory of predation. I do not find that government subsidies, contracts, and public ownership significantly affect the probability of predation. I also find little evidence to support any kind of reputation motivation for price wars. One variable which might support a reputation story *Time Since Last War* does not affect the probability of a price war. In particular, my results indicate that price wars in turn of the century shipping markets were not wholly the result of "mistakes" in private information, but also depended on commonly known entrant types. The significance of the size and age variables in predicting predation suggests that the long purse theory of predation, rather than signaling or reputation, was the dominant motive on the part of the shipping cartels.

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Table I: Price Movements around Price Wars				
Description	price before	price during	price after	exit?
FEFC forms 1893: textiles to China	30 pence	----	120 pence	---
Indian Mutual war to Calcutta 1891	258 pence	90 pence	NA	Yes
Austrian Lloyd war to Bombay 1881	20 rupees	5 rupees	20 rupees	No
Houston war to South Africa 1902	510 pence	192 pence at the lowest	NA	Yes
NYK war to Yokohama 1896	480 pence	300 pence	384 pence	No

Table II: Locations of Price Wars				
	South Africa	India	Far East	Total
Entries	24	12	11	47
Price Wars	7	4	3	14

Table III: Descriptive Statistics					
Variable	Obs	Mean	Std.Dev.	Min	Max
War	47	.298	.462	0	1
Weighted Route Tons	47	29069	29052	1686	146587
Route Tons	47	27854	24284	1449	126000
Firm Tons	47	78615	111181	1449	598203
Trade Growth	47	3.95	13.86	-13.94	52.68
Outside Opportunities	47	-2.90	12.34	-37.44	13.97
New	47	.298	.462	0	1
Subsidy Dummy	47	.340	.479	0	1
Contract	47	.213	.414	0	1
Publicly Owned	47	.213	.414	0	1
Age of line	47	29.62	32.96	0	135
Length of War (days)	46	79.24	200.09	0	960
Past War Percentage	47	.207	.154	0	.417
Time since Last War	36	4.78	5.13	1	25
Time since Last Entry	43	2.36	2.06	1	8

Table IV: Expected Signs of Variables under Different Theories of the Causes of Price Wars

Theory	Long Purse	Renegotiation or Signaling	Reputation	Cost
Route Tons		+		-
Firm Tons	-			
New	+			
Government Subsidy	+/-	+		
Contract	-	-		
Trade Growth		-		-
Outside Opportunities			-	
Time since Last War	+		+	

(A blank cell indicates the variable should not have an effect under that theory.)

Table V: Determinants of a Price War Conditional Upon Entry
Probit Specification

	(1)	(2)	(3)
New	1.57 **	1.07	2.09 **
	(.762)	(.883)	(1.23)
Outside Opportunities	-.088 **	-.080 *	-.128 **
	(.049)	(.053)	(.065)
Trade Growth	-.091 **	-.093 **	-.110 **
	(.044)	(.044)	(.056)
Firm Tons	-.180 *	-.210	-.226 **
	(.117)	(.153)	(.133)
Firm Tons 1q - dummy	-1.18	-1.30	-1.51
	(1.20)	(1.36)	(1.52)
Firm Tons 2q - dummy	-2.74 **	-3.31 **	-3.52 **
	(1.19)	(1.41)	(1.63)
Route Tons if lowest quartile	.987	.698	.868
	(1.11)	(1.19)	(1.51)
Route Tons if second quartile	.778	.909 *	.321
	(.608)	(.634)	(.807)
Route Tons if third quartile	.480	.395	.305
	(.445)	(.453)	(.528)
Route Tons if highest quartile	.089	.072	-.017
	(.133)	(.148)	(.163)
Time	.047 *	.068 **	.006
	(.032)	(.039)	(.056)
Contract	---	.925	---
		(.843)	
Subsidy	---	-.514	---
		(.734)	
Time Since Last War	---	---	.038
			(.092)
Time Since Last Entry	---	---	---
Constant	-.711	-.551	1.03
	(1.53)	(1.72)	(2.04
$\phi(\bar{X}\hat{\beta})$	0.230	0.197	0.190
Observations	47	47	36
LogLikelihood	-16.42	-15.52	-11.63

Standard errors in parentheses; * significant at 10% (one-tail test), ** significant at 5% level (one tail test)

Table VIa: Experience of All Entrants			
	Accepted	Unclear Result	Driven Out
War	8	0	6
No War	28	1	4

Table VIb: Experience of New vs. Not New Entrants			
	No War	War	Accepted
New	5	8	4 (1 unclear result)
Not New	27	6	32

Table VIc: Predicted vs. Actual Outcomes			
	War	No War	correlation: war and estimated probability
Correct Prediction	10	31	0.701
Incorrect Prediction	4	2	

Table VII: Comparison of Probit, MLE, and Semiparametric Estimates of the Determinants of Price Wars			
	Probit	MLE $\alpha_0 \neq \alpha_1$	MRC/IR
α_0, Probability that a true "No War" is misclassified	---	.065 (.045)	0 (undefined)
α_1, Probability that a true "War" is misclassified	---	.00007 (.481)	0 (undefined)
New	.680 (.330)	1.14 (1.05)	0.404 (.671)
Outside Opportunities	-.009 (.021)	-.123 (.088)	-.020 (.849)
Trade Growth	-.018 (.019)	-.127 (.101)	-.041 (.058)
Firm Tons	-.078 (.051)	-.078 (.060)	-.078 (.042)
Firm Tons 1q - dummy	-.511 (.520)	-1.18 (.994)	-.277 (.073)
Firm Tons 2q - dummy	-1.18 (.515)	-2.10 (1.26)	-.821 (.910)
Route Tons if lowest quartile	.427 (.481)	.348 (1.15)	-.158 (.632)
Route Tons if second quartile	.337 (.263)	.731 (.649)	.181 (undefined)
Route Tons if third quartile	.208 (.193)	.138 (.531)	.056 (.956)
Route Tons if highest quartile	.039 (.058)	.029 (.104)	.118 (.391)
Time	.020 (.061)	.031 (.038)	.036 (.191)
Observations	47	47	47

1. Because the estimates of α_0 and α_1 are zero, their standard errors cannot be calculated using the MRC/IR method; an adjacent step is necessary for standard error estimation.

2. One variable must be held fixed to calculate the standard errors for the Han coefficients. In Table VII it is *RouteTons if second quartile.*

3. The Probit and MLE results must be scaled in order to be able to compare them to MRC. The MRC/IR method only estimates the ratios of the coefficients, not their absolute magnitude. I chose a scaling factor which creates equal *Firm Tons* coefficients across the two methods. That scaling factor was then used on the other Probit and MLE coefficients.

4. The size of the window width used to construct the kernel for computation of the standard errors of the MRC estimates strongly affects the resulting standard errors. As the window width rises, so do the standard errors. The corresponding standard errors in Hausman and Scott Morton (1994) are not sensitive to the window width; the dataset in that paper has 5200 observations. I report results using a window width of 0.3, which gives reasonable standard errors; however, there is no general theory that gives an optimal window width for this method.

Table VIII: Determinants of Entry Tonnage OLS Regression[42]				
	(1)	(2)	(3)	(4)
New	-1.70 (.807) .042	-1.71 (1.04) .112	-1.78 (.839) .041	-1.71 (.802) .039
Outside Opportunities	-.055 (.027) .053	-.063 (.033) .068	-.056 (.030) .068	-.060 (.028) .036
Contract	1.89 (.858) .034	1.79 (1.07) .106	1.69 (.903) .070	1.86 (.853) .036
Subsidy Dummy	1.00 (.754) .191	.472 (.939) .619	.821 (.798) .311	1.06 (.751) .167
Firm Tons	.029 (.032) .371	.027 (.037) .473	.029 (.033) .399	.032 (.032) .331
Time	.039 (.033) .238	.011 (.059) .849	.055 (.040) .185	.016 (.038) .675
India Conference Dummy	-.716 (.814) .384	-1.56 (1.13) .180	-.968 (.906) .293	-.566 (.818) .493
Far East Conference Dummy	-1.43 (.770) .072	-1.92 (1.01) .070	-1.64 (.810) .052	-.762 (.940) .423
Time Since Last War	---	-.008 (.109) .939	---	---
Time Since Last Entry	---	---	-.205 (.180) .264	---
Past War Percentage	---	---	---	3.55 (2.92) .231
No. Obs.	47	36	43	47
Adjusted R^2	.317	.260	.327	.326

[42] Standard errors are in parentheses. p-values are in the third row.

Appendix I

Below are quotations from shipping managers' letters at the time of the entry of the Strick Line into the Bombay Trade. The correspondence reported here was saved by the Ellerman Line, a member of the Conference, and is now archived in the Business Records Library of Glasgow University.

Minutes of Meeting of the Bombay Steam Trade Conference
May 6, 1903
"Mr. Gill having returned from London reported that before proceeding further with the points already under review, there was a new and serious feature to take into account, namely the reported amalgamation between Messrs. Strick, Messrs. Bucknall and the West Hartlepool S.S.Co. in the Persian Gulf trade, who were stated to be endeavouring to get shippers in Manchester to sign contracts. Mr. Gill explained that he had discussed the whole matter very fully with the B.I.Co. [British India], and they were willing, in order to assist in defeating this opposition, to carry the goods on from Bombay to Persian Gulf Ports at cut rates, say one-third of whatever rate the West Coast Lines accepted through from Manchester, with a minimum of five shillings,..."

Minutes of Meeting of the Bombay Steam Trade Conference
July 3, 1903
"3) Persian Gulf Trade: Again discussed, and until Strick's next boat from Manchester was out of the way, it was agreed that the Conference Steamers should quote very low rates, down to 17/6 [17 shillings and 6 pence] if necessary, with the idea of specially punishing Strick by making him take unremunerative rates. After the departure of Strick's boat the matter to be reconsidered,...

"31st August, 1903
Dear Mr. Ellerman, [Ellerman Lines]

I have today been shewn the Letters between Sir George Mackenzie and Mr. Lloyd of the 14th and 17th July, by which it appears the proposal is to admit the Strick Line to the Bombay Trade from Newport by a monthly sailing, in consideration of the Line withdrawing from the Persian Gulf Trade and not taking cargo via Bombay to the Indian Coast, i.e., if you give up the Persian Gulf Trade we would negotiate for your admittance to the Bombay Trade from Newport.

It is further proposed that the Strick Line should stop competition from Bombay and Karachi cargo from Manchester and Liverpool, whilst the Bombay Lines are to discontinue carrying cargo to the Persian Gulf Ports via Bombay, and although this may be a good arrangement for the Strick and Persian Gulf Lines I fail to see how it can be of advantage to the Bombay/Liverpool Lines, and the reason for their advocating it.

You have always urged the necessity for the Bombay Lines loading from Newport, and I have agreed with you that it is to our interest to do so. There is no room for the Strick Lines and I am opposed to any negotiations for an arrangement with him. We must repel his attack, and if continued we should retaliate on the Persian Gulf Trade.

Yours faithfully,
C.W. Cayzer" [Clan Line]

Appendix II: Conference Histories

South Africa

The South African conference served the ports of the Cape Colony and Natal from both the East and West coasts of Britain (see Figure 3). The two founding lines were the Union Line and Castle Line. In the 1870s the South African Government gave each a half share in the mail contract to spur technological competition; the Union and Castle lines split the contract until 1900 when they merged. Meanwhile steamships were becoming more efficient and profitable and a spate of entry began. The Union and Castle lines felt sufficiently threatened to organize a formal conference in 1882 with two other firms. The conference established freight rates to be charged by all members and tightly regulated the number of sailings and ports of call allotted to each member line. The two mail lines worked closely in the conference, essentially deciding the rules for the other member lines; they kept the lion's share of sailings for themselves and negotiated favorable rate differentials for their faster (mail) ships. Additionally, South Africa did not export very much during the period - gold and diamonds were the major commodity exports - yet the colony demanded every sort of British manufactured good from railway ties to jam. Needless to say, the shipping lines did not have much volume in the way of "homeward," or UK bound, freight. The two mail lines expressly forbade the others from loading what little homeward freight there was, instead paying each line an annual subsidy in compensation.[43] The mail lines made substantial side payments on several occasions to settle disputes and most lines belonged to at least one revenue pooling arrangement. Though the cartel was disrupted by entry, price wars never arose because of internal disagreements alone.

Competition on the basis of price, though submerged, is occasionally visible in shipper actions. For example, a line could compete on the basis of price by absorbing wharfage dues, usually paid by the shipper, or by including some inland transportation, or by misclassifying freight. The rate differential between the faster mail ships and the slower cargo lines was also an area of continual disagreement, as each member line tried to implement a pricing policy favorable to itself.

A particular characteristic of South African trade was the strength of local merchant feeling against the monopoly power of the Conference.[44] On several occasions South African merchants who wanted an alternative to the conference encouraged entry without success. Local merchant associations occasionally formed their own line with charter ships, or threatened to, on all three routes. If the merchants were homogeneous and united, as in the case of Calcutta, they could gain. Most often merchants movements were too fractured to extract concessions from the conference, as in South Africa.[45]

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[43] In fact, a cargo line which "loaded homewards" was fined £2,000 by the conference! Solomon, E. (1982) p39.

[44] See Solomon, E. (1962) for a thorough description.

[45] According to Hyde, F. (1967 p97) conference pricing gave merchants one advantage, "...a uniform, continuous rate to make forward contracts with a certainty that no competitor by getting cheaper conveyance, can undercut

Calcutta and Bombay Conferences

The Indian conferences were naturally more disparate than the South African conference due to the geography of the route (see Figure 1). Some members continued on to the Far East, some to the Persian Gulf, some to the East coast of Africa, etc. The first Calcutta conference was formed in 1875 consisting of British India, the P&O, Hall, and City lines. All Indian tea was shipped from Calcutta or Ceylon; the Calcutta Conference agreed on the tea rate each year. Each line paid a percentage of its freight revenues into a common pool which was then allotted to lines in a certain proportion. No restrictions were placed on volume carried or number of sailings. Again, many side payments and other pooling arrangements also existed. For example, after Clan entered the tea trade in 1882, it was paid £2,000 per year by the P&O and £1,000 by British India not to carry passengers.[46]

On occasion a member would quit the conference and start a price war over some disagreement -- usually market share. I do not include these cases of war in the above analysis. A representative example of this type of behavior occurred in 1886 when Clan decided it would like a bigger share of the tea coming from the port of Calcutta (one of the stops in the India Conference). The other lines were not receptive, so Clan withdrew from the Conference and started carrying tea in special arrangements with plantations. The conference capitulated in the summer of 1887, giving Clan a larger percentage of trade. Motivations for such behavior were different from standard entry so the two types of observations are therefore not combined.

The Bombay Conference was initially formed in 1879. It set standard cargo and passenger rates, most importantly rates on Lancashire cotton piece goods from Liverpool. By 1885, its members consisted of the P&O, British India, Anchor, Harrison, Hall, Clan, City, and Rathbone. I can find 16 cases of entry occurring in the following years. Many entrants were resented and fought vigorously, others were given complex shared rights to certain ports and cargo.

Far Eastern Freight Conference

The original Far Eastern Freight Conference (hereafter FEFC) agreement included the P&O, OSS, Glen, Shire, Mogul, Skinner, and Messageries Maritimes (French) in 1879. The most valuable cargo of all heading to China was Lancashire and Yorkshire (L&Y) goods: yarn, wool, cotton, and silk manufactures. OSS, being based in Liverpool where the products were manufactured, had a virtual monopoly of L&Y goods. However, it paid shares of the L&Y revenue to other lines in the Conference which were forbidden to load at Liverpool.

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him or depreciate his stock." He thought merchants were worried about windfall profits and losses if freight rates, a large proportion of the cost of goods, were set by a free market.

[46] Muir, A. (1978) p133.

Although primarily British firms tried to enter in the early period of the FEFC, in the 1890s a new group of non-British lines began sending ships to China. A few nations which had interests or possessions in the region now had ocean-going steamships. Swedish and Italian lines are the main examples. Austrian Lloyd (Italian) entered Far Eastern routes in 1892; it was heavily subsidized by the Italian Government, but seemingly without a clear strategy in mind for the business of the line. In contrast, the government of Japan gave the FEFC's main competitor, the newly formed Nippon Yusen Kaisha (NYK) line, explicit goals. One was to keep export freight rates low. The Japanese government frequently denied rate increases to NYK on silk and cheap manufactures. The NYK bargained and muscled its way into the conference in several stages from 1893 to 1901. Government subsidies, special route subsidies, and specific rate requests on the part of the government considerably enhanced NYK's bargaining power *vis a vis* the FEFC.[47]

[47] Doug Irwin (1991) applies modern strategic trade theories to this period. He does not claim the agents knew what they were doing strategically, whereas the in this case the Japanese Government may well have been aware of the effects of its actions.

Figure 1

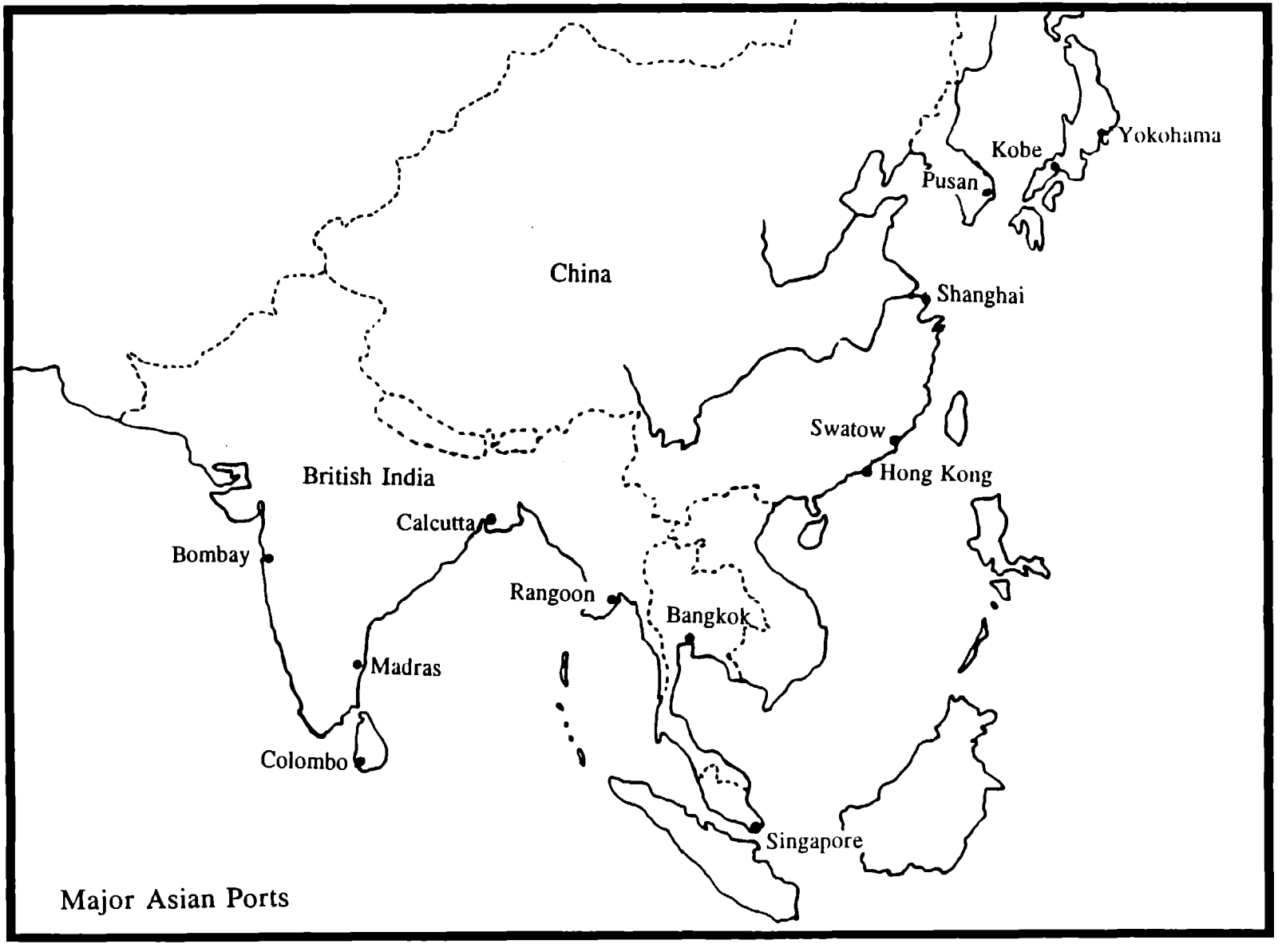
China
British India
Yokohama
Kobe
Pusan
Shanghai
Swatow
Hong Kong
Calcutta
Bombay
Rangoon
Bangkok
Madras
Colombo
Singapore
Major Asian Ports

Figure 2

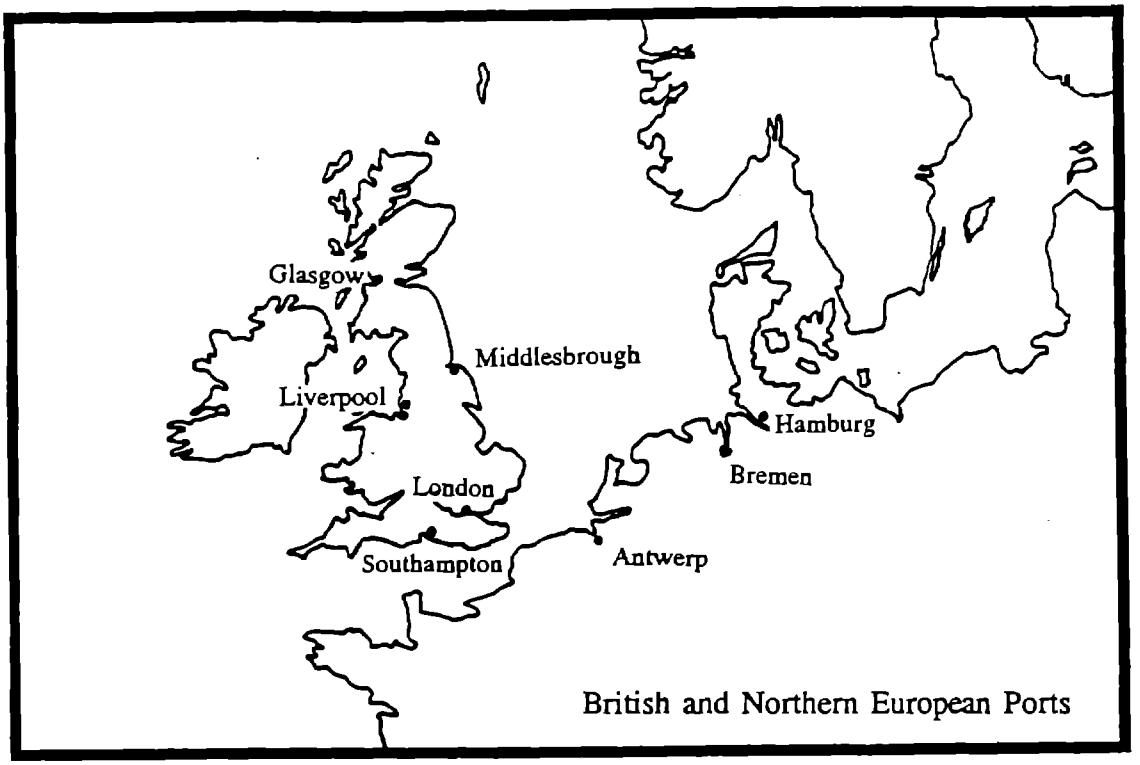

Figure 3