

**ALLIANCES AND CONCENTRATION:
THE ECONOMIC CONSEQUENCES OF MARKET STRUCTURE IN
THE LINER SHIPPING INDUSTRY**

by

John Bockrath

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics

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Any remaining mistakes belong exclusively to the author.

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ABSTRACT

Over the last twenty years a wave of consolidation has swept through the oceanic liner shipping industry, leaving the industry dominated by a handful of large firms, almost all of whom are involved in one of four major strategic alliances. As liner shipping is the dominant form of international transportation this shift in market structure could have a substantial impact of the global trading system.

There is surprisingly little attention paid to transportation issues in the extant trade literature and virtually no attention paid to liner shipping. To rectify this gap in the literature, I examine the economic consequences of these changes in the liner shipping sector's market structure. Using a simple model of international trade I show that, given the unique conditions in the liner shipping industry, strategic alliances have an ambiguous effect on trade volume, but that the conditions under which strategic alliances are beneficial to trade are a more plausible description of the industry.

I then empirically examine the relationship between liner shipping alliances and trade flows, using a unique data set with a geographic and temporal coverage not available in previous works. The empirical results show that there are some signs that alliances may be utilizing market power but this evidence is not consistent enough to warrant significant regulatory action. A legal analysis of the history of liner shipping regulation supports this conclusion by casting doubt on the effectiveness of the current liner shipping regulatory structure. In short, despite somewhat mixed evidence, there are reasons to believe that liner shipping alliances are beneficial to trade and that regulatory responses are unlikely to be productive.

Chapter 1

INTRODUCTION

Modern oceanic shipping is characterized by two types of services: specialized single good (bulk) transport, and “common carrier” liner shipping.¹ Liner shipping transports what are known as “general” cargo, any goods which need to be packaged for transportation and are not shipped in large enough quantities to fill a ship’s hold, requiring the shipping firm to carry a large variety of different goods on every voyage (Sjostrom 2004). Liner shipping firms transport cargo using strings of ships which operate on tightly fixed sailing schedules along a set port distribution, sailing regardless of whether or not the vessel is full. Modern liner shipping is almost entirely “containerized,” loading all cargo into thousands of standardized 20- or 40-foot containers. Liner shipping is the most economically important type of oceanic shipping and a vital component of the global economy; analysts estimate that liner shipping transports 60% of world trade by value (IHS Global Insight 2009). The liner shipping market has always had a unique market structure; historically, the industry was characterized by long standing legal price-fixing cartels known as “conferences.” However, a string of recent regulatory changes and increasing demand for globalized shipping has effectively destroyed the conference system (Federal Maritime Commission 2012)

The modern industry is now organized into a handful of loose collaborative ventures known as “alliances.” A wave of mergers has left the industry dominated by

1. Unfortunately, the terminology used to describe the actors in the shipping industry can be confusing. Despite the fact that the industry is called the shipping industry, “shippers” refers to firms who need to have goods transported (i.e., customers). Firms which actually operate vessels are called “carriers” or “shipping firms.” While all maritime terms will be defined as they appear in this research, Appendix A contains a glossary of the maritime terminology which is used in this thesis for reference purposes.

a small number of large firms, almost all of whom are involved in alliances with other large firms. Due to the economies of scale inherent in liner shipping these alliances could potentially generate significant economic benefits. However, if one views alliances as anti-competitive forces, then this shift in market structure has created substantial concentration in the liner shipping sector. To date, despite widespread interest in the liner shipping sector, there have been few formal efforts to examine how changes in this sector's market structure have impacted the global trading system. The relatively small literature that directly address shipping issues generally focuses on how changes in market structure impacts the profitability of shipping firms or the stability of the liner market itself (for example, Slack, Comtois, and McCalla (2002)). These works, which are generally published in industry-specific journals, do not consider the potential that shifts in market structure might impact the wider trading system, instead myopically focusing on intra-industry concerns.

The trade literature, conversely, generally downplays or ignores transportation issues and has paid virtually no attention to liner shipping. The extant trade literature's lack of interest in the liner shipping industry is surprising, given that it is widely acknowledged that trade costs are vitally important in the modern economy. Furthermore, it is well established that consumers have a preference for variety and thus that the heterogeneity of trade is an important source of welfare (Krugman 1981). Transportation issues could thus have significant impacts on global welfare; efficiency (or lack thereof) in the transportation sector will influence the level of trade costs, while transportation firms' decisions about which markets to serve will impact the set of foreign goods which are available to consumers in each nation. The market structure of the liner shipping industry will clearly influence the choices that liner shipping firms make. Thus, the market structure in the liner shipping industry almost certainly has significant impacts on the global economy and should be a matter of concern for the broader trade literature. The small trade literature that does directly address liner shipping is out of date, dealing with a market structure and legal environment that no longer exists. There is a glaring need to evaluate how the *current* market structure of

this industry is impacting the global trading system.

This thesis aims to fill this gap in the existing literature by examining how the emergence of the modern liner shipping alliance system has impacted the global economy. Rather than a myopic focus on the shipping firms themselves, this research focuses primarily on the economic impacts of these large-scale collaborative ventures. In an effort to analyze this issue as completely as possible this research presents three major sections which approach this topic using complementary but distinct methodologies.

Chapters 3 and 4 present a theoretical model of the global trading system with heterogeneous goods. This model explicitly incorporates a shipping sector, with the modelling assumptions behind this depiction of the shipping sector carefully calibrated to match the important characteristics of the modern liner shipping sector. Incorporating the possibility of strategic alliances into this framework generates theoretically motivated conclusions about the economic effect of strategic alliances. These results show that strategic alliances have ambiguous effects on the trading system; while they grant some market power they also provide technical benefits, with the total effect depending on the relative strength of these two effects. Analyzing simulated versions of the model establishes the conditions under which alliances either encourage or inhibit trade. This analysis demonstrates that the conditions under which alliances are beneficial to trade are a more plausible description of the industry, suggesting that liner shipping alliances are beneficial to the global economy.

Chapters 5, 6, and 7 present results from empirically examining how shipping alliances have impacted bilateral trade flows, utilizing a unique and, to the best of my knowledge, unprecedented data set which tracks liner shipping firm activities with a much wider temporal and geographic coverage than any previous research has been able to generate. Analysis of each of the major alliances reveals a shocking degree of similarity in each alliance's commercial behavior, suggesting that formal empirical testing is necessary to examine these alliances' economic impacts. The empirical results demonstrate that there is support for the prospect that alliances are beneficial to trade. However, these results also show some signs that alliances inhibit trade in a manner

consistent with market power, but the evidence for this proposition is not strong and generally does not survive disaggregation by alliance. Given the potential that alliances are beneficial to trade and the lack of consistent evidence for alliance market power, significant regulatory responses seem unlikely to be effective.

Finally, Chapter 8 examines the history and the evolution of liner shipping regulation on both a nation and international level in an effort to assess the feasibility and effectiveness of liner shipping regulation. This analysis casts doubt on whether the current liner shipping regulatory system possesses sufficient political will to carry out optimal regulation. This reinforces the conclusion that strong regulatory responses to liner shipping alliances are unlikely to be prudent, as the current regulatory system is ill-equipped to either create or enforce such regulation.

This research has important implications for how shipping alliances have and will impact the international trading system. As it is unlikely that the trend towards liner shipping co-operation will end, understanding the potential benefits (or pitfalls) of these arrangements will be vital for prudent regulatory decisions. On a deeper level, these results suggest that transportation issues can significantly impact trade, that seemingly “peripheral” issues like the transportation sector’s market structure can have substantial effects on the international trading system. This implies that (beyond any regulatory results) trade economists should be interested in transportation issues. More broadly, these results suggest that it is perhaps time to begin examining whether or not other seemingly “minor” issues which the trade literature has historically neglected might be worth exploring in more detail. Understanding the liner shipping sector is an important part of understanding the international trading system and this research provides the first serious effort to analyze this industry.

Chapter 2

LINER SHIPPING OVERVIEW AND LITERATURE REVIEW

2.1 Shipping Industry Literature

2.1.1 History of Liner Shipping Market Structure

Firms in the liner shipping industry were historically organized in groups called “conferences,” cartels that set price schedules for their members, restricted output, and engaged in price or quantity wars with outside entrants (Clarke 1997). Conferences were generally legal, with most nations granting the shipping sector anti-trust immunity in the name of preserving that nation’s maritime power. There was a long-running debate in the academic literature about whether or not these entities operated as cartels or as checks against “destructive competition.” On the cartel side, authors argued that conferences acted in a manner consistent with profit-maximizing cartels and were inhibiting the development of the global economy (Fox 1994; Francois and Wooton 2001; Jansson 1986). A number of authors conducted empirical studies that demonstrated that conferences seemed to inhibit the growth of trade in ways consistent with the existence of market power (Fox 1995; Fink, Mattoo, and Neagu 2002; Hummels, Lugovskyy, and Skiba 2009). Other works examined the actions of the conferences themselves and argued that they were consistent with cartel-like behavior (Fusillo 2003; Marin and Sicotte 2003). This strand of the literature claimed that conferences were precisely the cartels they appeared to be and frequently argued that conferences’ anti-trust immunity should be lessened or removed.

The liner industry itself maintained that there was something unique to liner shipping which would make pure competition detrimental to the global economy. While the versions of this “destructive competition” argument offered by the liner shipping

firms themselves were frankly implausible, a small subset of the academic literature argued that their conclusion was valid on the more arcane grounds that liner shipping suffered from an “empty core.” Broadly defined, “an empty core” is a situation in which there is no efficient competitive equilibrium (Telser 1996). In the case of liner shipping the most commonly offered argument was that production was “lumpy,” only producing output (tons of shipping capacity) in fixed quantities because ships have to be of a certain size to be seaworthy. Since the supply curve for shipping capacity would thus be discontinuous, if demand did not happen to be an integer multiple of this fixed quantity then the supply and demand curves could not intersect and the market would be inherently unstable (Sjostrom 2004).¹ In such a scenario, conferences might be economically beneficial as they could restrict the competition that led to market instability and thus impose a stable equilibrium. Several authors carried out empirical studies which suggested that the liner shipping industry had features consistent with this hypothesis (Sjostrom 1989; Pirrong 1992). Indeed, the shipping industry was often offered as the prototypical example of an “empty core” industry used to illustrate the concept when discussing other industries (Telser 1994).

This debate about the economic consequences of the conference system occurred primarily in the 1990s and never reached any widespread consensus. Indeed, how to view the conference system is still effectively an open question, albeit one that is more a matter of academic curiosity than a practical concern, as the conference system itself is effectively dead. In this case political systems moved faster than academic literature and regulatory changes caused the conference system to end before the academic literature reached a definitive conclusion about the system’s merits.

1. While the outcome of this debate is not relevant for this work, as an aside I do not personally find this argument compelling. While ships do have fixed tonnage sizes, shipping firms really produce combinations of quantity and quality (“shipping services” rather than shipping). The frequency of ship arrivals and the number of ports reached are vitally important to shippers. A shipping firm faced with excess or deficient demand for a fixed price could vary their quality level to encourage or decrease demand. The overall supply curve would then be continuous and there would be no integer problem.

2.1.2 The End of Traditional Conferences

While authors in the theoretical and empirical literature went back and forth, there was growing pressure in political circles for reform. This pressure led to several changes in the legal structure of the U.S. regulatory system in the 1980s, none of which fully satisfied either shippers or shipping firms. Continued discontent led to several attempts to reform the system in the mid-1990s, with arguments about these reforms serving as the genesis of the conference literature. This process culminated in 1998 when the U.S. passed the Ocean Shipping Reform Act (OSRA). Under OSRA conferences retained their anti-trust immunity, but were legally barred from restricting their member firms from engaging in sales outside of the conference structure. More importantly, conferences were barred from preventing their members from entering into independent “service contracts” (Lewis and Vellenga 2000).² This second requirement proved fatal for conferences on U.S. routes; in 2004 upwards of 80% of U.S. traffic was carried under a service contract, essentially neutering conferences’ pricing power (Wang 2012). In 2008 the EU went even further, outright removing liner conferences’ anti-trust immunity and thus rendering traditional conferences illegal under standard anti-trust law (Federal Maritime Commission 2012).³

The U.S. and the EU collectively represented the traditional centers of conference power, as conferences were never as prevalent on the routes to and from Asia, arguably because the older conferences attempted to actively exclude the younger Asian shipping firms which emerged in the latter half of the 20th century (Thanopoulou, Ryoo, and Lee 1999). These legal changes left the existing conferences essentially powerless. While there are still some conferences active in the world, they are restricted to smaller trades and economically irrelevant to the global economy. Any traditional

2. While exact details can vary depending on the companies involved, in general a service contract is an agreement for a shipper to provide a fixed amount of traffic per month which the shipping firm agrees to move on a certain timetable for some negotiated shipping rate. It is roughly equivalent to having a shipping firm on retainer. The details of these service contracts are strictly confidential to all parties outside of the transaction (including conferences).

3. These specific legal changes are covered in more detail in Chapter 8.

conference that attempted to move goods to the E.U would be strictly illegal, while any conference that attempted to move goods to the U.S. would have to accept service contract provisions that would make it trivially easy for their member firms to defect.

Thus, for all practical purposes the conference system is dead; furthermore, the conference system would most likely have ended regardless of legal changes. By the time of OSRA's passage it was fairly clear that the conference system was untenable. Shippers were increasingly demanding "intermodal" services which link the shipping part of the customer's supply chain directly into the ground portion of the supply chain by, for example, directly unloading containers onto rail cars. Furthermore, shippers were increasingly interested in truly international shipping, allowing them to use the same shipping firm for their business in multiple nations. Conferences had traditionally only operated on single routes and had resisted the rise of containerization and other innovations, leaving them ill-suited to respond to these changes (Levinson 2006). The shipping industry was ripe for a fundamental change in market structure.

2.1.3 The Modern Liner Shipping Industry

In response to the end of the conference system, concerns about overcapacity, and more sophisticated shipper demands, in the last twenty years firms in the liner shipping industry have begun entering into collaborative ventures known as "alliances." Alliances vary widely in their organizational structure, but broadly speaking an alliance is a set of individual firms that co-ordinate their vessel deployments, allowing them to serve a wider range of destinations and customers (Brooks 2000). These co-ordinations usually involve utilizing a pool of commonly provided vessels, which allows the alliance's members to justify building larger and more efficient vessels, as the alliance as a group can generate sufficient cargo to economically justify the larger vessel. Compared to conferences, alliances are less restrictive in their actions, as they are barred from restricting prices and allow independent competition amongst their members, even on the same routes the alliance operates on. However, alliances are much larger in scale than the traditional conferences, as many alliances collectively

Figure 2.1: Top-20 Firm Capacity Rankings

Rnk	Operator	TEU	Share	Existing fleet	Orderbook
1	APM-Maersk	3,017,968	14.7%		
2	Mediterranean Shg Co	2,681,372	13.1%		
3	CMA CGM Group	1,812,926	8.9%		
4	Evergreen Line	939,887	4.6%		
5	Hapag-Lloyd	918,819	4.5%		
6	COSCO Container L.	853,947	4.2%		
7	CSCCL	707,179	3.5%		
8	Hamburg Süd Group	643,552	3.1%		
9	Hanjin Shipping	620,770	3.0%		
10	OOCL	575,086	2.8%		
11	MOL	568,873	2.8%		
12	UASC	549,124	2.7%		
13	APL	528,968	2.6%		
14	Yang Ming Marine Transport Corp.	517,102	2.5%		
15	NYK Line	479,489	2.3%		
16	Hyundai M.M.	398,013	1.9%		
17	K Line	380,273	1.9%		
18	Zim	357,857	1.7%		
19	PIL (Pacific Int. Line)	352,497	1.7%		
20	Wan Hai Lines	216,365	1.1%		

span the globe and the combined membership of some alliances control substantial portions of the global shipping market.

During the same period the industry has gone through a number of mergers, especially amongst the European firms, which have left a few large companies in control of substantial portions of the global market (Sheppard and Seidman 2001; Sys 2009). Based on data from Alphaliner, a consulting firm which tracks data on the shipping industry, in February 2016 the top-10 shipping firms by shipping capacity controlled 62.4% of the total worldwide shipping capacity and the top-20 firms controlled 83.6% of worldwide shipping capacity. Figure 2.1 shows the percentage of global ship capacity controlled by each of the twenty largest firms in February 2016, based on data from Alphaliner.

As many of the non-top-20 firms are domestic firms dealing with cabbotage (domestic oceanic trade often protected from foreign competition) for all intents and

Table 2.1: Historical Alliances

Alliance Name	Initial Members	Notes	Year Formed	Year Dissolved
Maersk/Sealand	Maersk Sealand	Added P&O Nedlloyd	1994	2005
Global Alliance	OOCL MOL APL Nedlloyd MISC		1995	1997
Grand Alliance	P&O Hapang-Lloyd NYK NOL	Added MISC Added P&O Nedlloyd	1995	2011
The New World Alliance	HMM MOL APL		1997	2011
CKY Alliance	Cosco K Line Yang Ming		1998	2001
CKYH Alliance	Cosco K Line Yang Ming Hanjin		2001	2012

Table 2.1 is based on Agarwal and Ergun (2010) up to 2007 and Huang and Yoshida (2013) up to 2012. It treats an alliance as “dissolving” if it changes its name, even if the result of the dissolution was to simply reform with new members.

purposes the top-20 shipping firms effectively carry all international trade. This consolidation is a recent trend which has coincided (and some would say has been driven by) the increasingly wide use of shipping alliances. Shipping alliance began to emerge in 1996 with formation of the Maersk & Sealand alliance. The first set of alliances saw substantial instability; of the four major alliances formed in the first wave of consolidation around 1996 only one lasted more than two years in its original configuration (Midoro and Pitto 2000). Table 2.1 presents a brief summary of the history of alliance formation. To avoid an excessively long table, it only shows selected major alliances whose history is in some way connected to one of the major current alliances- a number of other alliances, some of them significant in size, are excluded because they ultimately

Table 2.2: Currently Active Alliances

Alliance Name	Initial Members	Notes	Year Formed	Year Dissolved
G6	Hapang-Lloyd NYK OOCL APL MOL HMM		2011	Still active
CKYHE	Cosco K Line Yang Ming Hanjin Evergreen		2012	Still active
P3 (planned)	CMA CGM Maersk MSC	Vetoed by Chinese regulators	2014	2014
Ocean 3	CMA CGM CSCL UASC		2014	Still active
2M	Maersk MSC		2014	Still active

Table 2.2 is based on Alphaliner & the author’s personal research. While Evergreen formally joined CKYH in 2014, they began heavily coordinating with CKYH in 2012 and this table presumes that Evergreen effectively joined CKYH in 2012 (JOC Staff 2014).

folded in a short period without influencing the current alliance system.⁴

Alliances are at this point the dominant organizational form in liner shipping. There are four major alliances named 2M, Ocean Three (O3), CKYHE, and G6; table 2.2 summarizes the memberships of these alliances. Comparing table 2.1 with 2.2 shows that the consistent trend in the liner shipping industry has been towards steadily larger alliances who collectively include almost every major shipping firm. Sixteen of the top-20 liner shipping firms by existing ship capacity are involved in one of the above four alliances (Davidson 2014). Three of the four who are not in an alliance (PIL, Zim, and

4. Almost all of this early instability was driven by the wave of mergers moving through the industry in the late 1990s. In 1997 the shipping firms P&O and Nedlloyd merged. As these two firms were in rival alliances at the time (respectively the Grand and Global alliances), this forced a reshuffle of the entire structure of the industry, reforming the Grand alliance with more members and re-branding the Global alliance as the New World alliance. The newly formed P&O-Nedlloyd again switched alliances later to join Maersk before eventually being acquired by Maersk in 2005.

Wan Hai Lines) are small (respectively 18th, 19th, and 20th in global capacity ranking in February 2016). The only substantial firm outside of the current alliance structure is Hamburg Süd, who is eighth in the world by capacity rankings. However, Hamburg Süd already co-ordinates heavily with the Ocean Three alliance and many analysts consider it only a matter of time before that alliance becomes “Ocean Four” (JOC Staff 2015). Despite some substantial volatility, with some firms having been involved in three or more major alliances in the last fifteen years, there is a clear consolidation trend in liner shipping market structure that has left the industry dominated by a handful of firms, almost all of whom co-ordinate heavily with other large firms.

2.1.4 Literature on Liner Shipping Alliances

There is little consensus in the academic literature about the economic impacts of this newly emerged alliance system. If one views alliances as a means to achieve technical efficiency while still competing commercially, then the trend towards larger alliances is an obvious net positive; there are substantial economies of scale in liner shipping that these new super-alliances will be able to utilize, especially in regard to the potential for rationalizing new “mega” size shipping vessels and offering a more diverse portfolio of potential services (Imai et al. 2006; Leach 2015). These larger vessels can attain substantial economies of scale, but very few firms generate enough cargo to justify constructing them. Alliance formation can solve this issue by pooling multiple shipping firm’s cargo together. For this very reason, the OECD, in a report arguing against continuing anti-trust exception for price-fixing arrangements in liner shipping, explicitly suggested that its member nations should retain an anti-trust exemption for “operational agreements” like alliances (section 201 and 202 of OECD 2002). Nor is it clear that shippers are opposed to shipping alliances; the best way to summarize shippers’ attitudes towards alliances is “ambivalent,” with many accepting the view that they achieve technical efficiencies which are beneficial to the trade system (Szakonyi 2015).

However, if one views shipping alliances as conferences or cartels in all but

name- a charge that has been leveled against them by shippers (Shingleton 2012)- then alliances amongst these larger firms have created enormous concentration in the shipping industry, much more concentration than ever existed in the conference system. For example, the members of the proposed P3 alliance would have controlled 42% of oceanic shipping capacity between Asia and Europe, enough to arguably allow them to operate as at least a very powerful oligopolist if not an outright monopolist (Bowman 2013). Even after the eventual veto of this specific alliance by Chinese regulators, the current market is dominated by the four major alliances, whose membership collectively controls roughly 75% of global shipping capacity. Many analysts believe that all major firms outside of the current alliance structure will either eventually join an alliance or be rendered irrelevant to the larger trading system (Leach 2014). If one views alliance pessimistically then the emergence of this alliance system has led to enormous increase in already-high market concentration.

To emphasize the scale of the modern alliance system, table 2.3 shows two sets of Herfindahl-Hirschman Indexes (HHI) for the liner shipping sector. HHIs measure how competitive a market is by summing the square of each individual firm's market share. This gives a number between zero and 10,000, respectively representing perfect competition and monopoly (Carlton and Perloff 2005). Both sets of HHIs only examine the top-20 firms, implicitly assuming that all of the remaining firms are small enough that they are not relevant for the global market. The first set of HHIs, the "optimistic" version, assume that alliances are technical agreements with no competitive implications, calculating the industry HHI treating each firm separately. The second set of HHIs, the "pessimistic" version, assume that alliances are mergers in all-but-name, treating each alliance's membership as a single firm.

As table 2.3 shows whether or not the liner shipping industry faces concentration concerns depends heavily on how one views shipping alliances. If alliances are purely technical arrangements, then there is little evidence of either current market dominance or a consistent trend towards more concentration. While the market is dominated by the twenty or so largest firms, capacity is sufficiently dispersed amongst the largest

Table 2.3: Alliance Impact on HHI Concentration

Year	Optimistic HHI	Pessimistic HHI	Percentage Increase
2011	582.7	911.59	56%
2012	641.67	1077.97	68%
2013	620.14	1073.44	73%
2014	620.46	1106.3	78%
2015	667.87	1714.15	156%

HHIs are based on capacity data from January 1st of each year, excepting 2015 which were gathered in April.
 All data are drawn from Alphaliner’s “Top 100 Firms” capacity rankings.

firms that competition is not unduly infringed. On the other hand, if alliances are able to co-ordinate in an anti-competitive manner then the growth of the alliance system has substantially increased concentration in this economically vital sector. Indeed, by this measure the formation of the 2M and O3 alliances in 2015 would have been presumed to have increased market power by the U.S. Justice Department, which considers any merger which increases an industries’ HHI by more than 200 to be problematic.

Despite the potential concentration concerns presented by alliances, regulatory bodies have largely treated them as purely operational agreements, focusing most of their attention on conferences and individual firms. However, with the conference system largely dead there is growing pressure for a formal evaluation of how anti-trust law should view shipping alliances (Bonney 2015; Dupin 2015). The sheer size of modern alliances has naturally led to more attention from anti-trust authorities. In addition, recent events have led to increased scrutiny of alliances. There is growing conflict between shippers and shipping alliances over congestion surcharges, which are fees that shipping firms charge to shippers when their products are delayed from delivery due to congestion issues. Shippers claim that alliances have contributed to the prevalence of these congestion issues because they utilize super-large vessels which are time consuming to unload and because alliances are using haphazard loading practices in Asian ports (Paris 2015).⁵ In effect, the accusation is that alliances are attempting to charge

5. Specifically, the claim is that on larger vessels (which are nearly always utilized in an alliances due to the costs of operating a ship in the 15,000 TEUs or higher range) containers are often being loaded randomly rather than being sorted by destination due to the sheer volume of containers in the

for a condition that they caused (Federal Maritime Commission [2015b](#)).

Regardless of the merits of these accusations, the pressure that they exert is likely to influence regulatory bodies in the coming years. Given the likelihood that this pressure will, much like OSRA, build to a critical mass and potentially lead to a formal regulatory response sometime in the next decade it is vitally important to formally evaluate the economic consequences of alliances in liner shipping so that regulatory bodies are armed with the information that they need to make informed decisions.

2.2 Strategic Alliance Literature

2.2.1 Strategic Alliances in the Broader Industrial Organization Literature

The above section explores the existing literature on strategic alliances that specifically relates to the liner shipping industry. However, liner shipping is not the only industry in which these forms of informal co-operation have become common (Anderson [1990](#)). Indeed, it is not even the only transportation industry in which alliances are common; alliances have become increasingly common in the aviation industry, especially the passenger aviation industry, and there is a literature analyzing those alliances (Brueckner and Spiller [1991](#); Barla and Constantatos [2005](#)). This extant literature on strategic alliances has generally examined two broad questions. First, scholars have examined why alliances exist- that is, what are the advantages of these loose forms of co-ordination over more formal types of co-ordination? Second, authors have grappled with the question of what (if anything) is the appropriate regulatory response to strategic alliances, a question that depends on whether alliances can exercise market power.⁶

ship. Upon unloading the cargo are then left stacked on the dock, forcing the port operators to sort them by destination, which causes delays and congestion.

6. In reality, there is actually a third strand of literature that deals with the value and stability of alliances in non-economic settings (traditionally in military situations). This section does not cover this literature; the models in this literature cannot be easily mapped into models of firm behavior as they tend to be very specialized for potential military or political purposes. See Bloch ([1995](#)), Sandler and Hartley ([2001](#)), and Esteban and Sákovics ([2003](#)) for overviews of this literature.

Alliances pose something of a conundrum for traditional industrial organization, in that there is not an obvious reason in standard Cournot models for these kinds of informal co-operation. While alliances that serve as essentially mergers might be justified in principal as a way to act as a monopolist while avoiding regulatory scrutiny, even those alliances are not entirely theoretically sound. In a classic result, Salant, Switzer, and Reynolds (1983) showed that when there are more than two firms competing under Cournot conditions an alliance or merger between two of the firms actually *decreases* the merging firms' profits. In Cournot competition firms impose externalities on one another with their production decisions; merging causes the resulting alliance or mega-firm to internalize the effects of those externalities, leading them to decrease their output. But this "retreat" causes any remaining firms to expand output in a way that leaves the resulting alliances less profitable. Later research applying this issue specifically to transportation issues has been unable to derive a satisfactory way around this issue in the context of Cournot competition (Barla and Constantatos 2006). Some authors have been able to justify alliances in a "contract" world in which firms can enter into alliances that commit to re-allocate profits using side payments to keep the alliance viable (Morasch 2000). While these are interesting exercises in game theory, such side payments are not generally observed in real alliances and it is not obvious that they would be either legal or credible.

More broadly, when considered through the lens of traditional "production function" conception of the firm it is hard to conceive of any justification for this sort of "halfway" co-operation. While it is possible to generate conditions under which either a pure merger or pure competition are optimal, it is much more difficult to generate conditions under which firms would co-operate while remaining separate and even competitive entities. Most of the efforts to do so have relied on ad hoc justifications of alliance benefits for forming firms, assuming that the resulting alliance can attain cost reductions or pricing benefits without explicitly analyzing *why* the alliance is able to do so (Zhang and Zhang 2006). While this may be a helpful methodology for analyzing

some of the mechanics of alliance formation and regulation it is too tautological to explain why alliances are beneficial in the first place and, more critically, why an alliance might be preferred to an outright merger. In practice, the industrial organization literature has not come to a satisfying conclusion on the reasons for alliance formation. This is not necessarily a flaw in this literature, as what it suggests is that there is no *universal* justification for alliance formation. That is, there is no over-arching set of conditions which can explain alliance formation in all industries. Rather, given that alliances do exist it seems reasonable to conclude that alliance formation is driven by the sort of local, industry-specific conditions that are largely abstracted from in more generalized “production function” industrial organization. Thus, much of this work focuses on examining how liner shipping alliances might be justified in terms of the unique conditions in the liner shipping industry without attempting to derive any general conditions for strategic alliance viability.

2.2.2 Shipping Alliances and New Institutional Economics

Traditional industrial organization has not produced a consensus view on strategic alliances, nor has it necessarily produced any reason to believe that they can or do exercise market power. Nevertheless, alliances have been viewed skeptically in many cases due to their non-traditional form. In many ways the skepticism towards alliances is an expression of a larger divide between traditional industrial organization thought and the “new institutional economics” first championed by Ronald Coase and popularized by Oliver Williamson. Traditionally, economists and especially anti-trust authorities had treated nontraditional firm structures with skepticism, assuming they were signs of market power and anti-competitive behavior (Williamson 1971; Shapiro 2010). Effectively, traditional industrial organization worked under the assumption that it was well established what a competitive market *should* look like and thus viewed any sort of behavior which did not fit into that structure with deep skepticism. This skepticism naturally led to a historical presumption against any sort of co-operation, a presumption which dominated regulatory thinking in the 1950s and 1960s.

In the 1970s a wave of new scholarship, led by Oliver Williamson, challenged this consensus. Following in the footsteps of Ronald Coase’s legendary 1937 paper on firm structure, Williamson and the authors he inspired argued that nontraditional firm behavior like vertical integration or exclusive franchises could resolve important economic dilemma and were thus potentially efficiency enhancing (Williamson 2010). Specifically, this literature noted that firms could use these structures to prevent potentially wasteful bargaining or mitigate the risk of opportunistic behavior by suppliers (Williamson 1985; Tadelis and Williamson 2012). The idea that this sort of behavior might exist to resolve micro-level disputes has given rise to a large and varied literature that documents the advantages and limitations of various nontraditional behaviors (Gibbons 2005). More deeply, this literature has led to an (exceedingly justified) expansion of humility amongst many regulatory decision makers who are now less likely to simply assume that any activity they do not understand must inherently be anti-competitive.

Unfortunately, despite seemingly obvious parallels, there have not been any direct intersections between the new institutional economics literature and the liner shipping literature. Despite occasional mentions of the *possibility* of some sort of micro-level justification for shipping alliances, authors in the liner shipping literature, of both the pro- and anti- alliance variety seem to be much more comfortable with traditional “technology based” conceptions of the firm (Button 2005). No academic work has formally examined whether or not alliances might be justified on transactions cost minimizing grounds, nor does there seem to be any interest in studying the question further in the extant literature. While the general regulatory approach to the liner shipping industry has largely reflected new institutional economics beliefs (being willing to consider the possibility that non-traditional market structures might be beneficial), no regulatory body has explicitly justified its actions in these terms.

2.3 Trade Economics Literature

2.3.1 Transportation Issues in the Theoretical Literature

The literature on the economics of trade has largely ignored transportation issues. Despite the lack of direct engagement with transportation issues, however, in many ways this literature has established that transportation issues are critically important to the global trading system. A long and diverse literature has established that the global economy is heavily impacted by the costs associated with moving goods across national borders, traditionally referred to as “trade costs.” In the theoretical literature, trade costs are the critical parameter in New Economic Geography models and a vital component in any modern trade model (Fujita, Krugman, and Venables 1999; Combes, Mayer, and Thisse 2008; Melitz and Ottaviano 2008). The equilibria in these models are generally functions of preference parameters (especially the elasticity of substitution) and trade costs. As preferences are generally viewed as either fixed or exogenous, the evolution of these models’ equilibria are dictated by the evolution of trade costs. Indeed, many works in this field graphically demonstrate their results as a function of trade costs, fixing the other parameters.

However, despite the central importance of trade costs in these models, the extant literature shows shockingly little interest in the determinants of trade costs, especially in the transportation sector. While all trade models will naturally include some form of trade cost, this cost is typically represented as an exogenous “extra” cost for any goods sold internationally. Specifically, most of the extant literature represents transportation issues as part of an “iceberg” trade cost. An iceberg cost models trade costs as given by some fixed percentage of the value of the shipped good, representing the idea that transportation is paid for by losing a chunk of each transported good’s value. It draws its name from the idea of shipping water in the form of an iceberg (so that some of the product melts in transit).

This approach is problematic on two fronts. First, the iceberg form itself is nearly certainly inappropriate for representing transportation costs. Rather than scaling directly with the value of the good like a tariff, actual transportation costs are

generally fixed based on weight. Some components of transport costs, such as insurance rates, may increase with the price of the good being shipped but at the very least a significant fraction of transport costs are fixed. High fixed costs imply that international trade is not content neutral; instead, trade will involve a disproportionate volume of goods with a high value per pound, as these goods incur a relatively low trade cost as a percentage of their final sales price. This idea owes its genesis to the work of Alchian and Allen (1964) and recent work has produced substantial empirical support for the concept (Hummels and Skiba 2004; Echazu 2009). Because transportation costs are the primary source of fixed costs in overall trade costs, this research suggests that transportation costs specifically can alter the distribution of trade by pricing goods with low value per pound out of the trade market.

Perhaps more importantly, the vast bulk of previously published research treats transportation as just another exogenous, given cost, regardless of whether or not they use an iceberg trade cost. This is not a trivial assumption: those authors who have incorporated an actual transportation sector have found that its inclusion can drastically alter the conclusions in many models (Behrens, Gaigne, and Thisse 2009; Behrens and Picard 2011; Takahashi 2011). The key point is that, unlike other barriers such as geography or tariffs, transportation costs are endogenous, determined by market interactions between shippers and carriers. Endogenous decision making means firms can influence one another and are aware that they can influence one another. As the above authors have shown, accounting for this strategic decision making produces results that are qualitatively different from the results that emerge from the simple exogenous trade cost case. For example, with fixed trade costs rising trade volumes do not increase the costs that need to be paid to export. Once one accounts for the transportation sector, however, it should be clear that rising demand must inevitably lead to increasing trade costs, muting the effect of whatever change in the world economy led to the initial rise in trade volumes. This is an important and intuitive outcome that is not captured in most standard trade models. Despite some recent work trying to incorporate more realistic depictions of trade costs, most authors continue to rely on trade cost forms that

are inappropriate. Even those authors who have begun to formally model the transportation sector frequently rely on production forms and market structure assumptions that are at odds with the actual realities of how the modern shipping industry functions. A more nuanced depiction of the shipping industry’s market and production structure would almost certainly produce different or at least more complete results.

2.3.2 Transportation Issues in the Empirical Literature

Empirically, an immense amount of evidence demonstrates that trade costs are a significant determinant for the level of trade, especially for poorer nations (Limão and Venables 2001). With the notable exception of Hummels (1999), there are very few attempts to directly estimate transportation costs primarily because of data issues which will be discussed in Chapter 5. Most empirical trade research instead estimates overall trade costs, which are an aggregation of all potential costs, including transportation costs, geographic barriers, and political barriers (Disdier and Head 2008; Anderson 2011). These costs measure how distance impacts trade but do not inherently allow one to determine the importance of individual components.

However there is considerable evidence that transportation costs are now the largest component of trade costs, eclipsing tariffs and other “traditional” trade barriers (Hummels 2001; Fink, Mattoo, and Neagu 2002; Hummels 2007). For example, Hummels (2007) found that in 2004 the median individual exporter to the U.S. paid \$9 in transportation costs for every \$1 they paid in tariffs. Much of the empirical literature estimating “trade costs” is in large part estimating transportation costs, as these are now easily the single largest component of trade costs. Thus, despite the paucity of direct estimates, there is a huge amount of work that implicitly estimates transportation costs through their connection with trade costs.⁷ In short, while the

7. To give an idea of the scale of this literature, Disdier and Head (2008) is a meta-analysis of gravity models based on a hundred and six separate articles. The authors freely admit this survey is not exhaustive: this trade cost literature is legitimately enormous.

extant literature has not directly engaged with liner shipping issues, current literature supports the concept that transportation issues can have substantial economic effects.

Unfortunately, despite how common research which measures trade costs is there are essentially no works which directly measure the extent to which oceanic shipping impacts trade costs or on how shipping impacts international trade. The lack of reliable empirical work on these issues does not truly reflect a failing amongst previous generations of scholars. Rather, it reflects the fact that historically data on transportation sectors, especially oceanic shipping, were virtually non-existent. In depth historical study of these issues was largely impossible, which led most authors to focus their efforts on the components of trade costs which could be more plausibly measured, such as tariffs. The few works which focused specifically on transportation issues were so limited in available data that they were forced to utilize methods that were flawed, as it was impossible to carry out more robust checks. However, as Chapter 5 will demonstrate, these data issues have become progressively less of a barrier and more intricate empirical tests are now feasible. The broader trade literature does not appear to be aware of these advances in data quality. It is telling that when many authors mention the impossibility of empirically examining transportation issues they cite Hummels (1999) which, while an excellent piece of research, is nevertheless seventeen years old and does not necessarily accurately reflect the state of current data availability. The extant literature has established the importance of transportation costs and advances in data quality has made it feasible to empirically examine these issues.

Chapter 3

A BASIC THEORETICAL MODEL OF LINER SHIPPING

This chapter presents a simple model of the international trade system which formally incorporates the liner shipping sector, both in the sense that it includes a transportation sector (instead of representing transportation issues with an abstraction such as iceberg trade costs) and in the deeper sense that this transportation sector is modelled in a way which captures the essential features of the *liner* shipping sector. I derive equilibrium results for this model under a variety of different simulations to draw conclusions about how the shipping sector impacts international trade. These results suggest that the realities of the shipping sector can significantly impact the trading system (absent any market structure concerns).

The model is then expanded to allow firms to co-operate in ventures called “shipping alliances.” The liner shipping sector has long argued that their industry has unique characteristics which make co-operation beneficial to the global economy. The representation of liner shipping alliances used in this model is explicitly designed to test this hypothesis by relying on a representation of liner shipping alliances which is quite harsh, representing these alliances as virtual cartels which compete with their creators. This makes it possible to examine whether or not the unique characteristics of the liner shipping market make co-operation beneficial and, if so, in which situations this beneficial co-operation will occur. I examine how the introduction of these shipping alliances impacts the equilibrium results for the simulations used earlier in the chapter to derive some conclusions about the economic effects of shipping alliances.

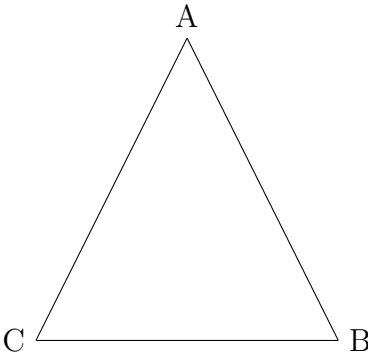
The model in this chapter relies on an abstract depiction of the production and consumption sides of the market, representing them in a simple way to preserve a tight focus on the shipping sector. However, in principal there is no reason that

the shipping sector as depicted in this model -or any similar depiction of the shipping sector- could not be incorporated into a more complete model of international trade. Indeed, one of the goals of this research is to argue that the trade literature could find considerable value in more closely examining some of the “peripheral” issues which the literature has historically ignored. While this research’s primary goal is analyzing the economic consequences of shipping alliances, the results will hopefully serve as a proof of concept that there is considerable value in expanding the focus of international economic research to a wider range of issues.

3.1 A Triangular World

When discussing transportation issue it is necessary to carefully specify the “structure” of the world; how many nations there are and how the routes which link them are geographically distributed. This chapter’s goal is to establish the basic features of the model used in this theoretical research. Throughout this basic explanation it is presumed that the world is arrayed in what could be considered the simplest possible configuration of the global trading system, making it easier to explain the model’s core features. Specifically, the entirety of this chapter presumes that the global trading system is structured as a “triangular” world, a 3-port (or nation) system, denoting the ports A, B, and C, with each nations directly linked to every other nation. This gives a trade structure similar to a triangle, something like figure 3.1.

Figure 3.1: Triangular World Diagram



Note that while figure 3.1 displays routes of equal length, implying a high degree of symmetry in trade costs and distances, there is nothing in this structure which requires this symmetry. Different assumptions about the cost of shipping between nations can allow for non-symmetrical structures, such as an “intermediate port” structure in which one port is the “middle,” with a short distance between A-B and B-C and a substantial distance between A-C, or a system in which two ports did not have a connection.

While the imposition of a three port system may seem like an extreme abstraction, in reality these concerns about the “structure” of the world (the distribution of routes between each ports) are far more significant than the number of ports. The results in the following sections would be qualitatively similar for a larger number of ports, as long as the way those ports were connected in the same basic way (each port connected directly to every other port). Adding more ports would simply increase complexity.

A three port system is an imposition only to the extent that it prevents modelling any system whose basic form requires more than three ports. For example, with only three ports it is impossible to represent a system in which each nation was connected to its immediate neighbors but not directly connected to at least one other nation in the world. Chapter 4 presents results based on a more elaborate port structure, one which cannot be depicted with three ports but which much more strongly captures the routing structure used in the modern shipping system.

3.2 Exporting Firms

3.2.1 Output and Prices

Assume that each nation has a single exporting firm or, alternatively, that it is possible to represent the actions of all of that nation’s exporting firms with one representative firm. To keep modelling complexity to a minimum production is fully abstracted; instead, each exporting firm is endowed with T units of their respective goods in each period. I assume that each nation’s T is stochastic. Each firm has to

decide how they wish to split their sales of these goods between the home and foreign markets based on the prices in each nation.

For an exporting firm in nation i , shipping internationally to country j requires the exporting firm to consume one unit of a shipping firm's product, at a cost of τ_{ij} . Denote firm i 's sales in market j as F_j^i (with F_i^i equal to their sales in their home market) and the price they can receive in market j as P_j^i (with P_i^i the home sales price). Letting k be the third nation, each exporting firm faces the following maximization problem:

$$\begin{aligned} \max_{F_i^i, F_j^i, F_k^i} & P_i^i F_i^i + P_j^i F_j^i + P_k^i F_k^i - \tau_{ij} F_j^i - \tau_{ik} F_k^i & (3.1) \\ \text{subject to } & T_i = F_i^i + F_j^i + F_k^i \end{aligned}$$

It is possible to have zero trade flows if the gap in relative prices between two nations is substantial enough; theoretically, a natural autarky state is possible if international shipping is exceedingly expensive. Standard non-negativity constraints are imposed throughout the theoretical analysis but are excluded from equations for brevity.

In any of the three markets the price the firm can receive for their products is assumed to be decreasing in the amount they sell to that market and increasing in the prices of competing goods. The second assumption implies that these goods are imperfectly substitutable, keeping the core modelling assumptions in line with modern trade literature's focus on differentiated goods. Formally, with i as exporting firm's home nation and j as the sale market (noting $i = j$ is the price in the firm's home market), firm prices are assumed to be given by:

$$P_j^i = \alpha - F_j^i + \beta \left(\sum_{y=-i} P_j^y \right) \quad (3.2)$$

A pricing equation with this form could arise from maximization of a utility function in which goods are imperfectly substitutable. This model thus implicitly assumes that consumers have a preference for variety, but does not directly specify a utility function

to keep the consumer portion of the model as simple as possible.

3.2.2 Exporting Firm Equilibrium Results

Given the price system defined by equation 3.2 it is possible to derive the relationship between the quantity sold in each market and the prices the firm can expect in that market. Inserting this relationship into equation 3.1 generates equilibrium results for the quantity that each firm will ship to each market. Equation 3.3 presents the optimal quantity shipped from nation i to nation j , with all parameters positive and k as the third port.

$$F_j^i = \frac{T^i}{3} - 8\zeta\tau_{ij} + 4\zeta\tau_{ik} + 2\zeta\tau_{kj} - \zeta(\tau_{ji} + \tau_{ki} + \tau_{jk}) \quad (3.3)$$

This result has a fairly intuitive explanation: in a world of zero trade costs each exporting firm would sell exactly one third of its output in each market to minimize the degree to which their prices are depressed by their own sales choices. Once non-zero trade costs are introduced firms deviate from this one-third outcome based on the *relative* prices in each market after trade costs. A high level of τ_{ij} depresses trade to j because it lowers the return from exporting to j : conversely, a high level of τ_{ik} increases trade with j because it decreases the return from trading with k (raising the return in j relative to the return in k). A level of high τ_{kj} drives down exports from k to j , increasing prices in j . The other terms divert trade towards j , decreasing prices in j . Trade decisions depend on relative prices.

Solving the above system for shipping prices creates the inverse demand curves which shipping firms will use when determining how their pricing decisions impact the demand for their services. Equation 3.4 presents the inverse demand curve for shipping services from i to j , with k as the third port and all parameters positive.

$$\tau_{ij} = \gamma_0 T_i - \gamma_1 T_j - \gamma_2 (F_j^i - F_k^i) + \gamma_3 F_k^j + \gamma_4 F_i^j + \gamma_5 F_i^k - \gamma_6 F_j^k \quad (3.4)$$

Equation 3.4 is based on the intuition that exporter demand for shipping from i to j

depends on the differences between prices in j and world prices and that prices for each good are decreasing in own quantity sold but increasing in the quantity sold of other goods.¹ Thus, increasing F_j^i decreases prices in j due to market saturation, naturally decreasing demand for shipping from i to j and therefore driving down equilibrium shipping prices. Increasing F_j^k drives down demand for shipping to j because it has the same impact on prices in j .

Conversely, shipping demand from i to j is increasing in F_k^j and F_i^j because as the quantity that firms in j sell in their home market decreases all prices in j will increase. Similar logic explains why F_i^k increases F_j^i : as k ships more to i it decreases prices in i and encourages firms in i to sell abroad.

The sign on F_k^i may seem odd; as more goods are shipped from i to k prices in k will decrease, which presumably will divert trade towards i and j . However, firms in i have an advantage selling in i (as they don't need to pay shipping costs); thus, trade diversion occurs primarily towards the home market. Another way of putting this intuition is that any increase in i 's shipping abroad will tend to be drawn primarily from the amount they ship to the other market, rather than from what they sell in the comparatively cheap home market, which implies that as F_k^i increases demand for shipping from i to j decreases.

3.2.3 Allowing for Variable Levels of Demand

Up to this point the model has implicitly assumed that all nations have an identical level of demand, as it has assumed that α is constant. While this assumption is convenient for deriving baseline results, as it means that α drops out of the system in equilibrium, it limits the applicability of the model to more realistic situations. Thus,

1. All of the signs in equation 3.4 reverse if $\beta > .5$. When $\beta > .5$ the equilibrium price for a good will increase when more of that good is sold in a market, as the goods are such heavy substitutes that increasing the sales of good i in nation j causes other firms to decrease their shipping to j by enough that the price of i further rises. In this situation, shipping firms will respond by charging higher prices when quantity increases in a market, co-opting some of the exporting firms' gains. This would lead to exceedingly odd results, as it implies a positive relationship between shipping prices and quantity carried. Thus, from this point on, it is assumed that $\beta < .5$.

later sections of this research will sometimes allow demand to vary across nations. Specifically, these sections will replace equation 3.2 with the following firm pricing equation:

$$P_j^i = \alpha - F_j^i + D_j + \beta \left(\sum_{y=-i} P_j^y \right) \quad (3.5)$$

where D_j is a “demand shock” term which allows nation j to support higher price levels and thus, implicitly, higher demand levels.

For simplicity, the baseline results assume that $D_j = 0 \forall j$. Including these D_j terms doubles the number of items in each equation, which would make the results notationally dense. More importantly, these price shock terms impact trade in an intuitively expected way; a positive shock to the prices in any nation encourages all firms to sell their output in that nation, driving up trade volumes and shipping prices *to* that nation while driving down trade volumes and shipping prices *from* that nation. Including these terms in the baseline results would thus greatly increase the complexity of the equilibrium results while not illuminating any unexpected relationships.

3.3 Shipping Firms

I assume that there is one shipping firm per country, leaving the world with three total shipping firms. These shipping firms are limited by their nation of origin; in the absence of any co-operation they can only operate on the routes attached to their origin nation. So, for example, the shipping firm in nation A can operate along routes A-B and A-C but cannot function along route B-C.

Shipping firms produce “voyages,” output that must be consumed on a 1-to-1 basis for international shipping; for example, an exporting firm which wishes to ship one unit of output from A to B must consume a “voyage” produced by a shipping firm operating on that route. These voyages can be thought of as a generalization of the specific output that shipping firms create, rolling together the concepts of available space (capacity) and frequency of port visits. For notational purposes let Q_{ij}^p denote the number of voyages produced (or the quantity transported) by the shipping firm in

p from port i to port j (where p might be either i or j)

3.3.1 Entry and Cost Decisions

Shipping firms are assumed to have two production-related decisions: entry and quantity. Each shipping firm must decide before the uncertainty in output is resolved whether or not they wish to enter each market they have access to. Entry into a shipping market incurs a number of fixed costs for the shipping firms, most notably the cost associated with constructing or chartering and then organizing the necessary vessels. There is no practical way to recover these costs in the short run because liner shipping firms commit in advance to shipping schedules. Most liner shipping firms cannot cancel services after scheduling them, as the shipping firm has already committed to carrying output for some customers. Let E_{ij}^p denote firm p 's entry choice on route ij , with $E_{ij}^p = 1$ denoting entry and $E_{ij}^p = 0$ denoting non-entry.

I assume the cost of operating on a specific route is given by the following “entry cost” function:

$$TC(E_{ij}^p) = \begin{cases} 0 & \text{if } E_{ij}^p = 0 \\ \xi & \text{if } E_{ij}^p = 1 \end{cases}$$

This representation of entry decisions does *not* presume that firms must select a level of capacity: in this model a firm either operates or not, and once it is operating on a route it can transport any volume of output. This representation thus explicitly ignores capacity issues for a firm which has chosen to operate, such as a firm not having sufficient vessels to carry all demand. There are two justifications for this choice. First, this analysis only seeks to capture the essence of the shipping industry for the purposes of analyzing the economic impacts of market structure issues, rather than creating a formal model that can capture all of the complexities of the liner shipping industry. Models which attempt to fully represent the industry (accounting for issues such as formal capacity constraints) do exist, but including formal capacity constraints in an even moderately dynamic model is *profoundly* complex, to the point where these models generally have no analytical solution and often require incredible

efforts to even approximate (see, for example, Song et al. 2005). Including specific capacity constraints generally imposes such mathematical burdens that expanding the model to analyze any issues beyond capacity or cost decisions is effectively impossible.

Equally importantly, in the modern shipping industry there is a extremely active charter market: shipping firms faced with unexpectedly high levels of demand will often temporarily charter vessels to carry the excess output. Shipping firms thus rarely find themselves capacity constrained in the sense of having to turn away customers at their current price; instead they find themselves constrained by having to rely on more expensive and less efficient temporary options, increasing their costs and thus presumably their prices. Thus, the reality of modern shipping firms' potential capacity limits is better captured in the representation of production costs, rather than entry costs. While there are sunk costs in liner shipping it is not the case that these sunk costs impose a hard limit on the quantity each firm could carry.

After each firm has made their entry decisions the uncertainty in output is resolved and each shipping firm then competes in quantities carried along each route they have access to, subject to the implied shipping demand created by the exporting firm's problem and each shipping firm's entry decisions. Producing one unit of shipping services along a route incurs a cost that is rising in the quantity shipped. Denote firm p 's unit cost on route ij as $C(Q_{ij}^p)$.

I assume that this $C(Q_{ij}^p)$ function has two components. First, producing at all implies a minimum level of costs in the shipping industry beyond the cost of building vessels. These fixed costs include the minimum fuel costs necessary to move the vessel as well as various infrastructure costs and rental costs that come from operating in any given port. These costs are denoted σ .

Vessels also incur direct costs from operation which do scale with Q_{ij}^p , such as labor costs, the extra fuel necessary to move heavier ships, and insurance costs. Denote these costs as η . Thus, the shipping firm's unit costs are given by:

$$C(Q_{ij}^p) = \sigma + \eta Q_{ij}^p \tag{3.6}$$

In many of the following sections equilibrium results are presented in terms of σ , while η will usually be simulated. High levels of fixed costs are often offered as an explanation for why the shipping industry has unique market structures; for example, such fixed costs were one of the principal justifications offered for the conference system. Thus, σ 's effect on the equilibrium outcomes is uniquely interesting for this industry. Conversely, η is a fairly standard cost term; it is not generally significant except to note that it is a positive number that is sufficiently large to discourage corner cases like infinite shipping.²

3.3.2 Profit Maximization

Once shipping firms decide which routes they operate on their profit maximization process is quite simple. Specifically, defining O as the set of *other* shipping firms, each firm p has a profit function along each route ij given by:

$$\begin{aligned} \Pi_{ij}^p &= \tau_{ij}Q_{ij}^p + \tau_{ji}Q_{ji}^p - C(Q_{ij}^p)Q_{ij}^p - C(Q_{ji}^p)Q_{ji}^p \\ \text{subject to } F_y^x &= Q_{xy}^i + Q_{xy}^O \text{ for } x, y \in (i, j), x \neq y \end{aligned} \quad (3.7)$$

Each shipping firm's overall profit function is the sum of each of the individual profit functions for each route they operate on; overall profit maximization selects quantities on each route which jointly maximizes the combined function. Due to the connections between shipping prices on each route and quantities on all other routes this joint maximization will produce qualitatively different results than maximizing profits on each route separately. Solving this problem yields optimal quantities in terms of the parameters in the model.

To illustrate the intuition behind firm decisions making, the following equations present the optimal quantities each shipping firm would select if all firms operated

2. At the same time, it is often impossible to derive tractable results when both η and σ are left parametrized; these results are invariably equations with dozens or hundreds of terms which are effectively impossible to analyze. Simulating η provides manageable results while sacrificing nothing of significance to the analysis.

along all connected routes and all nations had identical levels of demand. Each firm has two optimal quantity equations, depending on whether the shipping firm is located in the shipping destination. The optimal Q s shipped from nation i to nation j (letting k be the third nation and with all parameters positive) are given by:

$$Q_{ij}^* = \alpha_1 T_i - \alpha_2 T_j + \alpha_3 T_k - \alpha_4 \sigma \text{ if the shipping firm is in } i$$

$$Q_{ij}^* = \beta_1 T_i - \beta_2 T_j - \beta_3 T_k - \beta_4 \sigma \text{ if the shipping firm is in } j$$

A high level of T_i will drive prices for i down; firms will respond by trying to spread their goods more evenly around the world, leading to a boost in shipping demand. Similar logic explains the negative sign on T_j : because trade is home biased a high T_j level implies low prices in j , driving down demand for shipping from i to j .

The interesting sign is T_k , output in the third market, whose sign flips depending on where the shipping firm is geographically located.³ High values for T_k imply a worldwide glut of that good, which drives down all prices, especially in k due to the home bias in trade. Changes in T_k have different effects on a shipping firm's optimal quantity depending on whether or not the firm has access to the i to k route. The shipping firm *in* i sees a sudden drop in the amount of demand along the i to k route. As their route access perfectly matches the route access of i 's exporting firms they respond the same way firms in i do, intensifying trade away from k . The shipping firm in j does not see a similar effect; instead, they simply see lower prices in i . In effect shipping firms are *home biased* in their transportation efforts because their global access is aligned with the access of their home firms.

While these Q^* s are the results of maximization when all firms compete on all routes, the optimal Q s in other firm entry configurations are generally similar. The basic intuition behind these results is unchanged in all cases; shipping firms respond to higher shipping demand by somewhat raising prices to co-opt demand and respond

3. This result technically depends on the level of β : extremely low β values support T_k being positive for both types of firms, although the equations still have different parameters.

to lower shipping demand by dropping prices to avoid a total lack of demand for their services.

3.3.3 Simple Shipping Firm Equilibrium

The results from maximizing equation 3.7 determine whether a shipping firm chooses to enter a route or not. Based on the optimal quantity that will be shipped given entry choices, shipping firms compare the expected profits from entry vs. non-entry, entering a route if the change in expected profits is greater than the cost of entry.

For a fixed set of assumptions about other firm's entry choices this process is simple. It becomes substantially more complex once firms must consider other shipping firm's entry choices. This is because there are 2^r possible entry levels, with r equal to the number of firm route decisions (in the triangle world this is equal to 6, so there are 64 possible outcomes). Manually considering each decision would be time consuming and almost certain infeasible for any model with more firms or ports

To avoid these issues, equilibrium in this research is found through simulation. Formally, I determine equilibrium by running through stages, calculating the expected profits given some distribution of firms and then seeing if any firm could increase their expected profits by altering their current entry choices. In many cases this process is relatively simple because firms are symmetrical in important respects and many entry choice combinations can be eliminated as impractical- for example it is unlikely that a firm will completely shut down and many times there is an obvious route upon which all firms will operate. While it is possible that searching for equilibrium using this process way may miss some equilibria, I believe that the potentially missed equilibria are fringe cases rather than any serious representation of how the shipping market works.

To illustrate the mechanics of this approach, imagine that no firm is operating along route ij . Firm i , then, would consider whether or not its expected profit from entry is greater than the cost of entry. If so, i will enter. However, firm j will make a

similar calculation. There are thus two outcomes: if j 's entry given i entering would also be profit-enhancing then both firms operate along this route. More interesting is the case where it is profit-enhancing for only one firm to enter: in this case I allow for the possibility of mixed strategies, of which the only valid option is clearly entrance with a probability of $\frac{1}{2}$ by each firm.

These mixed strategies vastly expand the set of potential equilibrium; for the sake of keeping the model tractable mixed strategies will only be considered in the case when a route can support more than zero but less than the full number of firms. Thus, the following equilibrium results explicitly ignore the possibility that a route can support two firms but that a mixed strategy might be profit enhancing. This implicitly assumes that shipping firms have a strong preference against uncertainty; they strongly prefer guaranteed entry, turning to partial entry only if there is no profitable guaranteed entry strategy.

The following section presents basic results from this maximization process for two different simulations to derive baseline results before examining liner shipping alliances.

3.4 Basic Results

3.4.1 Symmetrical World

Consider the following simulation:⁴

$$E[T_A] = E[T_B] = E[T_C] = 10$$

$$\beta = .4$$

$$C[Q_{ij}^k] = 5 + 5Q_{ij}^k$$

4. There is no need to specify the value of α beyond assuming that it is high enough that all exporting firms make a non-zero profit.

This is a “balanced” world where expected output is identical in all three countries. It is the simplest possible representation of the world for this model and thus an efficient way to illustrate the equilibrium search process.

The only real question here is to determine firm entry decisions. It is trivial to show that all firms will operate along at least *one* route for any plausible level of entry costs; because the world is symmetrical it does not matter which route each firm operates along and each firm is arbitrarily assigned an initial choice. It can easily be shown that if firms A & B (or any two firms) are each operating along one route then firm C (or the remaining firm) would choose to operate along a second route as long as $\xi \leq 11.22$ ⁵.

If this were true, then in response firm A would enter into a second route as long as $\xi \leq 10.82$. In this case B would enter the final route if $\xi \leq 10.4$. There are thus four potential outcomes: either every firm operates as a monopoly due to high entry costs, the firms play mixed strategies in which each firm enters a second route with $p = \frac{1}{3}$, the firms play a mixed strategy in which each firm enters a second route with $p = \frac{2}{3}$, or each firm competes on all routes if entry costs are sufficiently low.

The second and third results are unstable; even jointly they are only supported by a thin range of $\xi \in (11.22, 10.4)$. This section only analyzes the economic consequences of the first and fourth case, when the world is “divided” by high entry costs ($\xi > 11.22$) or when all firms operate due to low entry costs ($\xi < 10.4$), as it is unlikely that the other cases are plausible long-term outcomes.⁶

Unsurprisingly, competition is beneficial to trade and harmful to shipping firms, as under competition shipping firms have lower profit.⁷ Shipping volumes are much

5. These solutions and the solutions in subsequent sections were derived using Mathematica. The code for these derivations is available upon request.

6. Even minor deviations in the level of entry costs can render each equilibria unworkable, which implies that if there was any uncertainty about ξ they would almost certainly not emerge.

7. In a manner that is comfortably familiar in microeconomics shipping firms would prefer higher entry costs, as such costs allow them to credibly commit to not entering new markets and thus preserve monopoly profits.

higher when all shipping firms operate on all available routes. In the monopoly case each nation exports roughly 19% of its output, while in the all-enter case each nation exports about 27.5% of its output. These values are roughly in line with existing trade figures, which suggest that in 2014 roughly 24% of global GDP was exported.⁸ These higher output levels do not benefit exporting firms much as the extra competition cuts the price they receive in the home market such that firm profits are largely unchanged.⁹

Instead the primary beneficiaries are (implicitly) consumers, who see a larger variety of goods from different nations, giving them a more even distribution of their consumption between products from all three nations, albeit still with a heavy home bias. Prices converge somewhat (the cost of foreign goods goes down while the cost of home goods goes up) and shipping prices fall by about 17%. However, entry costs may well prevent that competition from occurring, harming international trade. This was a traditional argument for co-operation in the shipping industry, and at least in this simplistic version of the world it has some merit.

3.4.2 Symmetrical Non-Simulated Results

For the most part this research focuses on deriving results when the model is simulated, focusing on the implications of the model rather than attempting to formally solve it (formal solutions are available but in many cases they have dozens or hundreds of terms which make these solutions extremely difficult to analyze). Still, wherever feasible it is enlightening to demonstrate the form of the results with minimal

8. This rough figure is derived by combining data on total nominal merchandise exports from the World Trade Organization (available at https://www.wto.org/english/res_e/statis_e/statis_e.htm) with data on global nominal GDP from the World Bank's "World Databank" (available at <http://databank.worldbank.org/data/download/GDP.pdf>).

9. Due to the abstract way production was handled, this is true in general in this model; firms do not increase their production when shipping prices fall. Prices do not thus generally decrease because global output is unchanged; instead prices converge, with less of a boost to home prices versus foreign prices. Output prices have limited value due to the model's form and these results will generally focus on exporting volumes and shipping prices.

simulation. Thus, consider the following simulation:

$$E[T_A] = E[T_B] = E[T_C] = T^*$$

$$\beta = .4$$

where T^* is a positive constant. Without specific values for σ or η the resulting profit functions are lengthy (even in this simple set up there are over thirty terms). However, in output terms the resulting equations are actually quite simple. For any plausible values of σ or η shipping firm profits take the form:

$$\Pi = A_1 - \text{Entry Costs} - A_2 T^* + A_3 (T^*)^2 \quad (3.8)$$

where each A is a function of σ , β , and η , all positive, with $A_1 > A_2 > A_3$ for all firm entry decisions.

In general, then, profits are rising in the quantity of output in the world but over certain lower ranges of T^* an increase in output value can have a negative effect on expected shipping firm profits. There is a heavy home bias in trade: at relatively low levels of T^* each exporting firm sells almost all of its output in its home market. Increases in T^* at that point decrease prices in the home market, making it harder rather than easier to ship goods to foreign markets. Beyond a certain point, however, the home markets are saturated and exporting firms must turn to the international market to preserve profitability.

There is a consistent pattern in how entry impacts profits: when a shipping firm enters a new market, all else equal, every term in that shipping firm's profit function increases in absolute value, while entry by any other shipping firm causes each term in the original shipping firm's profit function to decrease in absolute value. Entry amplifies a shipping firm's exposure to international trade, while competition diminishes the amount of output each shipping firm can carry and thus the extent to which changes in T^* impact their profits.

3.4.3 A as the Dominant Economy

To expand the model to a more interesting situation, consider the following simulation:

$$E[T_A] = 30$$

$$E[T_B] = E[T_C] = 10$$

$$\beta = .4$$

$$C[Q_{ij}^k] = 5 + 5Q_{ij}^k$$

In this variation A is a major economy while B and C are relatively small economies. For plausible entry cost levels, shipping firm A will operate along both of its available routes, while shipping firms C & B will certainly operate along their route attached to A, taking advantage of the large flows of trade generated by A's high level of output. Entry costs sufficient to prevent these entry choices would lead to total firm shutdown. A's position grants it superior profits to both B and C as it can ship along both of the major trading routes.

The more interesting question is whether firms will operate along the smaller B-C route. Operating along said route will decrease profits along the routes connected to A; if firms in B and C are only able to sell domestically or to A then the volume of trade carried on A will increase, as will the profits derived from shipping to A. While this effect is not large enough to outweigh the profits from ignoring the secondary route if entry costs are zero or negligible, for higher entry costs shipping firms may choose to only focus on the larger trades.

Specifically, firms will abandon B-C if faced with entry costs that are even moderately high. If $\xi > 18.2$ both shipping firms will completely abandon this route, which is an entry cost threshold that is high but not implausible given the shipping firm profit levels in this simulation. For example, if $\xi = 18.3$ then if B attempted to enter B-C, all else equal, he would be paying an entry cost equal to 45% of his final profits. If $\xi > 12.2$ -a not particularly high threshold- then the B-C route can only

support one shipping firm, leading both smaller shipping firms to play a mixed strategy of entry with probability .5.

This mixed strategy is a highly inefficient outcome, as it leaves a 25% chance of both firms entering (bad from the shipping firm's perspectives) and a 25% chance of a profitable trade being shut down (bad for the global economy). While this model does not explicitly capture utility costs from this uncertainty it is intuitively appealing to believe that such uncertainty is a sub-optimal outcome beyond any profit implications (that uncertainty in-and-of itself is costly).

In terms of output, trade volumes are high in this world; if all shipping firms operate along all routes roughly 30% of worldwide output is exported, primarily along the routes connected to A (output moved between B and C accounts for only about 4% of global exports). Shipping prices are extremely unbalanced; prices for shipping a good from A are about eight times higher than shipping prices to A, while shipping prices on the B-C route are about half as large as shipping prices to A to encourage shipping along this relatively undesirable trade.

When entry costs are high enough to completely deter entry into the B-C route trade volumes decrease, falling to around 25% of global output. At the same time shipping prices from A increase by about 1% and shipping prices to A increase by about 20%. More importantly, though, the mix of global trade becomes much more imbalanced; consumers in B and C cannot consume output from the other smaller nation. Given a preference for variety this decrease in product variety is likely to have a significant effect on consumer utility.

In the case when only one firm is expected to operate along the B-C route expected trade volumes are not largely decreased, with roughly 28% of the global output exported, although expected shipping prices do increase by about 8%. However, this situation carries considerable uncertainty for all parties, which in-and-of itself is damaging to global welfare. This simulation demonstrates how even mild variations from pure symmetry can create situations in which the nature of the shipping industry can have dramatic impacts upon the global trading system, an outcome which an

abstraction such as iceberg trade costs cannot capture.

3.4.4 A as a Dominant Economy Non-Simulated Results

Rewriting section 3.4.3 without simulation implies the following set of parameters:

$$E[T_A] = \theta T^*, \text{ with } \theta > 1$$

$$E[T_B] = E[T_C] = T^*$$

$$\beta = .4$$

The addition of θ does not alter the form of profit equations, which are still identical in form to equation 3.8. However, θ “amplifies” the terms in those equations: $\theta > 1$ causes A_2 to be more negative and A_3 to be more positive. Furthermore, it is possible to explicitly define the output gap size at which firms B and C will abandon the B-C route, denoted θ^* .

Given values for T^* , ξ , and the other parameters in the model, B-C will be abandoned for values of θ between one and θ^* , as in that range there is a sufficiently small amount of market saturation that it is profitable for exporting firms to focus on only the larger trade routes. For any θ s greater than θ^* B-C will not be abandoned, as with that volume of global output there is sufficient market saturation to encourage demand for shipping along the smaller route, emphasizing that market saturation (or lack thereof) is the driving force behind this result.

3.5 Shipping Alliances

3.5.1 Incorporating Shipping Alliances

This section expands the model by allowing shipping firms the possibility of forming alliances with other shipping firms. Alliances formation decisions are made before entry choices, although the entry choices firms would make in the absence of alliance formation will impact alliance formation decisions. Alliances will only be

formed if they are profit enhancing; to be feasible an alliance must grant each firm a higher expected profit level than it would receive under the “no alliance” outcome.

To capture the spirit of modern alliance formation, in this model alliances work by effectively creating a third firm operating on some specific route or set of routes that at least one alliance member has access to. That alliance firm takes the place of the forming firms, all of whom now ship zero output along that route or routes. This new “firm” maximizes its own profit myopically, placing no weight on the profits of its creator firms. This can give rise to a sort of internal competition in which the alliance seems to compete with its forming firms by selecting output levels whose global effects are negative for the forming firms (mirroring the fact that many liner shipping firms effectively compete with alliances they are members of).

Alliances split their profits evenly amongst the member firms. This allows the alliance’s member firms to avoid part of entry costs for the alliance routes, since they need only pay their share of the alliance’s ξ instead of a full ξ for each route the alliance covers. This captures one of the principle arguments for co-operation in the shipping sector, which is that alliances allow firms to avoid fixed costs by combining fleets.

To keep a tight focus on analyzing how alliances impact trade (avoiding getting bogged down with modelling internal negotiations) I do not allow shipping firms to deviate from their alliance choices. In effect, alliance commitments are assumed to be binding, implicitly assuming that shipping firms, being large global institutions which must frequently interact with other firms, place a high value on being seen as trustworthy.

This leaves the following order of events in the model;

1. Alliances are formed.
2. Entry choices are made.
3. Output uncertainty is resolved.
4. Shipping firms (or alliances) select output carried along each route.
5. Trade occurs.

3.5.2 Equilibrium with Alliances

The possibility of alliance formation vastly expands the list of potential entry outcomes. This makes the previous method of examining every “feasible” outcome when attempting to determine the equilibrium outcome unworkably complex. Thus, I adjust the equilibrium concept used when solving this model in the presence of alliances.

From this point only subgame perfect Nash equilibrium will be considered, treating the system like a two-stage extended form game. In stage two each shipping firm makes decisions about their entry choices in the absence of alliance formation. In stage one each firm considers potential alliance formation; under the subgame perfect Nash equilibrium concept when the firms make these alliance formation decisions they compare the potential profits from alliance formation to the profits they would receive if alliances were not an option, or the Nash equilibrium of the “entry without alliances” subgame.

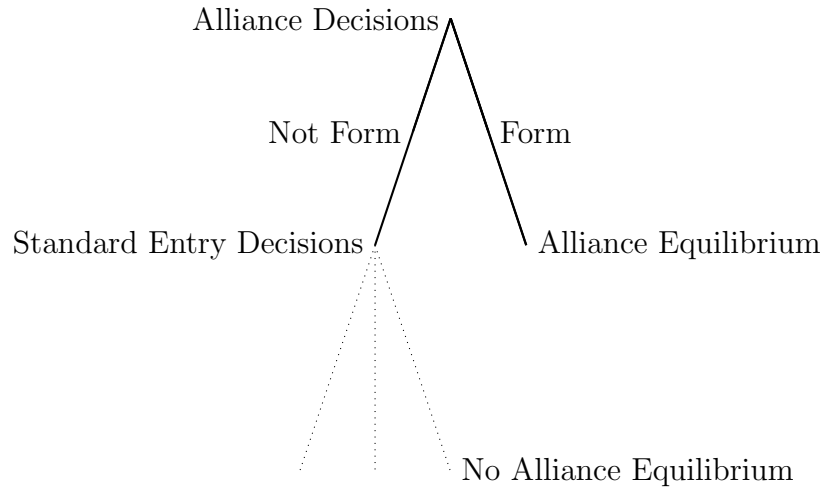
It is thus possible to summarize this approach with the game tree depicted in figure 3.2. Each line in this figure represents the spectrum of choices at each stage of the process.¹⁰

This is equivalent to imposing the condition that each firm’s entry choice strategies in the absence of alliance formation must satisfy Nash equilibrium conditions even if the firm forms an alliance. This removes any entry strategies that do not satisfy optimal conditions in the absence of alliances, vastly reducing the set of potential equilibria.

When there are only two shipping firms the above process summarizes every aspect of the game, as the resulting alliance involves both firms and it makes no sense to talk about how firms would “respond” to alliance formation. However, in the triangular world used in this chapter there are three firms, which means it is necessary to consider how the third firm might respond to alliance formation (assuming that

10. Given the assumptions of effectively full information and profit maximizing firms in effect the alliance formation process itself is a 0-1 choice (either form or not form); the assumptions about how the world and firms work simply dictates the payoffs from formation

Figure 3.2: Alliance Formation Game Tree



only a two-way alliance is optimal). In many cases this will be irrelevant (the firm will continue playing the entry choice decisions it would have used), but it is possible that the newly formed alliance will somehow change what the third firm wishes to do. In this case imagine that there is a third set of entry choices beginning with the alliance equilibrium, with the third player making his profit maximizing choice in that subgame (that is, alliance formation may alter the third firm's entry decisions).

The following sections examine how the introduction of shipping alliances impacts the equilibrium results presented in section 3.4.

3.5.3 Alliances in the Symmetrical World

To illustrate how alliances work in practice this section analyzes how alliance formation impacts the equilibrium results in the symmetrical world presented in section 3.4.1. Recall that the stable baseline outcomes are that either all firms compete on all routes or that each firm operates as a monopoly on a single route depending on the magnitude of entry costs. Due to the symmetry of this simulation it is possible to arbitrarily examine the effect of alliance formation (there is no need to specify which specific routes the alliance operates on).

When entry costs are low enough that all firms are operating on all routes then

firms A & B will decide whether or not to enter into an alliance on their connected route based on how this new alliance would impact their profits given that C is operating along both routes. This potential alliance between A and B exposes them to a stronger level of competition from the newly formed alliance. Furthermore, C's expected profits actually increase with the entry of an alliance, which is a standard result when dealing with coalitions in Cournot competition. Given high entry costs, however, this cost is outweighed by the advantage of avoiding some fixed costs and alliances are profit enhancing; specifically, if $\xi \geq 3.72$ then the advantages of avoiding multiple entry costs outweigh the harm to subsidiary trade.

Using a similar process, it is possible to show that an alliance across two routes that one of the member firms operates along (say an alliance between A & B on A-B and A-C) is not profit enhancing for firm A, whose losses from being completely replaced by the alliance outweigh the benefits from reduced entry costs. Similarly, an alliance between two firms on a third route (say an alliance between A and C on A-B) is not profit enhancing for the connected firm. An alliance along two evenly split side routes (say an alliance between A and B that operates on B-C and A-C) similarly fails to enhance profits as it saves no entry costs.

When entry costs are high enough that each firm operates as a monopoly, a "grand alliance" between all three firms on all routes will be preferred to the monopoly case as it provides a higher profit level. This option is also preferred to the competitive case except when entry costs are low ($\xi \leq 2.4$). This is because the grand alliance internalizes the effect that its quantity choices on each route have on the profits from shipping on every other route. This inevitably causes the newly formed alliance to carry less output along each route to preserve profitability on other routes, whereas more fiercely competing firms would carry higher overall quantity level. At very low entry cost levels this decrease in quantity shipped outweighs the value of decreasing entry costs. There are thus four total outcomes; if $\xi \leq 2.7$, no alliance is preferred. If $\xi \in (2.4, 3.72)$ a grand alliance is preferred. At intermediate levels of entry costs, $\xi \in (3.72, 11.2)$ both a single-route alliance and the grand alliance will be preferred to

the competitive outcomes and if $\xi \geq 11.2$ then a grand alliance is again preferred.

The exact effect that alliances have on the world thus depends on the level of entry costs; however, these effects are universally negative. A grand alliance is extremely damaging to trade volumes. For example, if a “grand alliance” replaces the monopoly situation then the amount exported falls from about 19% to about 17% while shipping prices increase by about 4%. Consequently, all prices rise in all markets, while shipping firms receive higher profits. This effect is even more pronounced if the grand alliance is replacing competitive firms in a situation in which entry costs are sufficiently high that a grand alliance would be justified.

Single route alliances have a less dramatic but still overall negative effect. These alliances cause overall trade volumes to decrease slightly (by about 2 percentage points), but trade into the non-alliance-route port actually increases as the alliance’s use of market power shifts trade in that direction. For example, an alliance on A-B leads to higher A-C trade. A similar pattern emerges in shipping prices; the alliance charges high prices on its route, which causes all other shipping prices to increase. The effect on the “other” routes are considerably smaller, however, shifting trade in that direction; in this simulation alliances both depress the level of trade and distort the distribution of trade.

Alliances in this simulation are an overall negative force, as they encourage market power abuse while providing no direct benefits, as there’s no plausible outcome that prevents trade from occurring between all ports.

3.5.4 Alliances without Parametrization

As established in section 3.4.2, without parametrization firm shipping profit functions for some symmetrical output level T^* take the form:

$$\Pi = A_1 - \text{Entry Costs} - A_2 T^* + A_3 (T^*)^2$$

Alliance impact the numerical values of the parameters in this equation. Alliances allow firms to partially avoid entry costs. A firm operating on two routes faces a total entry cost of 2ξ ; if the same firm forms an alliance on one of those routes it only faces an entry cost of 1.5ξ . However, alliance formation causes all of the other parameters (A_1, A_2 , and A_3) to decrease in absolute value, as the alliance represents a stronger form of competition, in the sense that when an alliance replaces the firm on a specific route the alliance's maximization of profits on that route does not take into account how its quantity choices impacts the original firm's profits on *other* routes.

Holding entry costs constant, then, in the case of comparatively high levels of T^* this loss will outweigh the benefit of splitting entry costs; when there is a high volume of available traffic then the damage from stricter competition will outweigh the benefit of lower entry costs. Alliances will therefore fall apart as the volume of output in the world increases; each shipping firm will choose minimize the competitors they need to face and accept higher entry costs. Conversely, if entry costs are high relative to potential trade volume alliance will be an extremely viable option to enhance profitability.

3.5.5 Alliances when A is a Dominant Economy

This section examines how alliance formation impacts the equilibrium results of the simulation in 3.4.3. Under this simulation it is reasonable to assume that B and C will be the primary candidates for alliance formation; A is in a dominant position and has relatively little incentive to share its route access with lesser firms. For A there are only two plausible alliances: an alliance between A and a non-A firm along the A route when all firms operate on all routes and an alliance between A and a non-A firm on the B-C route when that route has been abandoned due to high entry costs.

Neither of these alliances are feasible under this simulation. Under the first alliance, the smaller firm receives lower profits from giving up its direct connection with the larger market, while under the second alliance the dominant firm does not gain sufficient profits from access to the smaller route. Under this simulation a grand alliance

will never form, as A is not willing to share equal access with the other firms. These results illustrate why other alliances involving A will in general not be feasible; any alliance connected to the A route involves surrendering a route which is too valuable, while any alliance involving the B-C route grants the A firm too little profit to justify the expansion of competitive pressure.

Alliances between the two non-dominant firms in B and C are a far more interesting prospect. An obvious candidate would be longer alliances which operated on both non-A routes, i.e., B and C forming an alliance on A-B and A-C. However, this alliance is not feasible; for any level of entry costs the non-alliance alternative is preferable. An alliance of this form does not save either firm entry costs (as they would both operate on their respective A routes anyway) and the resulting alliance leads to lower shipping volumes as the alliance internalizes its own impact on the other route's trade.

The most interesting potential alliance is an alliance formed between B and C along B-C in the cases when firms are playing either a mixed strategy or abandoning that route entirely. When that route would be abandoned, alliances do not change the equilibrium result; they do not provide enough of a boost in profits under this simulation to justify entry.¹¹

However, if firms are playing a mixed strategy then each firm's expected profits in an alliance are higher for all levels of entry costs. In effect, alliances can solve the co-ordination problem posed by higher entry costs by dividing said costs, creating a more stable equilibrium. This alliance is trade enhancing; in expectation, total trade volumes rise slightly and prices fall slightly, by about 2 and 3.5 percentage points respectively. Furthermore, this alliance substantially reduces uncertainty about trade volumes, further enhancing global utility. The alliance is a net benefit to the trade

11. However, it is near certain that under a fairly similar simulation they could be justified as the gap between expected profits here is relatively small; were this to occur, alliances would provide an enormous benefit to the trading system by "re-opening" trade between two previously disjoint ports.

system in this case, as it allows firms and consumers to avoid uncertainty and ensures more reliable service between ports.

3.6 Theoretical Results from the Triangular World

This section summarizes the major conclusions that one can draw from the simple triangular world, conclusions that will be referenced in later chapters. It would be possible to extend this simple model further by examining how shipping firm entry decisions and alliance formation impacts equilibrium outcomes in other three-port simulations. However, the ultimate goal of this research is to analyze how shipping firms impact trade in a structure that is far more realistic and these two example simulations are sufficient to establish the basic mechanics of the model.

The results for the two simulations considered here imply that;

1. **Relatively High Entry Costs Depress Trade:** Based on the results in section 3.4, higher entry costs lead to route abandonment, encouraging shipping firms to only operate on a subset of routes. This depresses trade volumes and suggests a mechanism by which the nature of the shipping industry may well impact both the volume and composition of trade.
2. **Moderately High Entry Costs Lead to Uncertain Trade:** As the results in section 3.4.3 demonstrate when entry costs are moderately high shipping firms are tempted to abandon smaller routes entirely or to give them only intermittent service. While obviously the concept that shipping firms actually *randomize* their entry is impractical, translating that prediction into more realistic terms suggests that high entry or opportunity costs may lead to service that is either intermittent or poor quality.
3. **When Entry Costs are Low Alliances Inhibit Trade:** As the results in section 3.5.3 demonstrate, if all firms are operating on all routes then alliances are not trade enhancing; instead, they allow the shipping firms to utilize market power which depresses trade and increases alliance profitability. Another way of putting this result is that if the nature of the shipping industry is not actually inhibiting trade flows then there is no reason to believe alliances would be beneficial.
4. **When Entry Costs are High Alliances Encourage Trade:** As the results in section 3.5.5 demonstrate, if entry costs are high enough that firms do not operate on all routes then alliances can be trade enhancing, as the increase in

market power is counteracted by more widespread trade access and product heterogeneity. Or, if the nature of the shipping industry would naturally inhibit trade then it is entirely possible that alliances could be beneficial despite the possibility of market power

5. **Alliances are More Likely to Form Between Similar Firms:** As the results in section 3.5.5 show, when A is a “dominant” firm it has little incentive to form alliances as doing so weakens A’s dominant position. However, alliances are almost always justified between similar firms, both in the symmetrical and the non-symmetrical worlds, as the split in that case is relatively “even.” This suggests that, in general, alliances are more likely to be justified between relatively similar firms as in that case alliance formation does not upset any power dynamics.

Chapter 4

A HUB-AND-SPOKE MODEL OF LINER SHIPPING

4.1 Hub-and-Spoke World

4.1.1 World Structure and Exporting Firms

This chapter extends the model presented in chapter 3 to analyze a port structure that is more complex than a simple triangle but considerably more representative of modern ship routing, a structure referred to as a “hub-and-spoke” system. In this structure the world is divided into two halves by a major geographic barrier (traditionally an ocean or channel). Only one path links the two halves, with the ports on either side of that connecting path as natural hubs and the ports away from this connecting path as natural spokes. This is a structure that is extremely relevant in the current shipping system; modern shipping systems generally ship the vast majority of cross-oceanic trade between a handful of major ports.

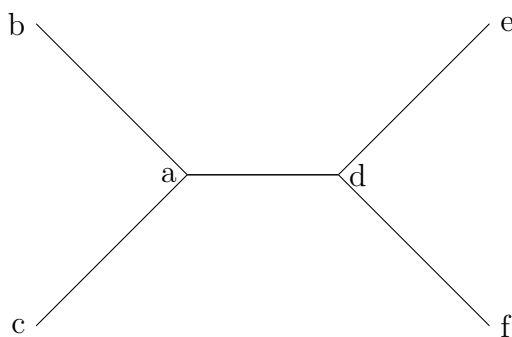
This tendency to focus trade is the result of both technical and geographic realities in port capacities and ship sizes. As ships become larger it becomes increasingly commercially optimal to focus trade on the routes between a handful of major hub ports, to ensure that there is sufficient cargo to fill the larger vessels, then disperse that cargo to its true destination in smaller vessels. Growing ship sizes limit the set of ports which can physically handle these larger vessels, as the largest container ships require substantial capital investments and deep bays. This second factor limits the number of potential ports to those who happen to be physically capable of handling that traffic.¹

1. While it is technically possible to artificially dredge bays deeper, this process is extremely expensive and would most likely require the port to cease operation for some time.

Thus, expanding ship sizes strongly encourage “hub-and-spoke” routing patterns. Given the rapid increases in ship sizes over the last twenty years, it is entirely possible that soon all cross-oceanic trade will end up essentially automatically routed between a handful of major ports. It is thus vitally important to determine how shipping alliances will impact trade flows in this system.

This structure can be summarized with the diagram of ports shown in figure 4.1, in which a and d are the hubs and b, c, e, and f are the spokes.

Figure 4.1: Natural Hub-and-Spoke Diagram



This world requires a slight modification of the exporting firms’ technology. In the simple triangle world each firm could potentially export to every other country without a need for a multi-stage trip. In this structure, however, there is not necessarily a direct link between many nations; it would be odd to assume trade between non-adjacent nations is impossible. Thus, in the hub-and-spoke structure, I assume that firms in each nation can trade with any other nation as long as there is a shipping firm connecting the two nations. Exactly how these “multi-step” trips work will be fully explained in section 4.1.2: from the point of view of the exporting firms it is enough to establish that it is possible to trade between any two nations i and j by paying τ_{ij} , as long as there exists at least one shipping firm operating on the (potentially several step) “route” between i and j .

All other basic assumptions about exporting firm behavior are retained; there is one exporting firm in each nation, each of whom is endowed with a set of imperfectly substitutable goods denoted T and which must decide in which nations they wish to

sell their output. Formally, letting N represent the list of nations in the world, each exporting firm's profit maximization problem is given by:

$$\begin{aligned} \max_{F_j^i} \sum_{j=N} [P_j^i F_j^i - \tau_{ij} F_j^i] \\ \text{subject to } T_i = \sum_{j=N} F_j^i \end{aligned} \quad (4.1)$$

Noting that $\tau_{ii} = 0$. Output prices are given by:

$$P_j^i = \alpha - F_j^i + \beta \left(\sum_{y=-i} P_j^y \right) \quad (4.2)$$

Equation 4.2 defines a 36 equation system for the price of each good in each nation. This system can be solved to derive prices in terms of the quantity of each type of good sold in each nation. Using these pricing equations one can easily derive the equations for the optimal quantity shipped between any two nations, which are formally given by (with all parameters positive):²

$$F_j^{i*} = \frac{T_i}{6} - \gamma_1 \tau_{ij} + 5\gamma_1 \left(\sum_{k=-j} \tau_{ik} \right) + \gamma_2 \left(\sum_{k=-i} \tau_{kj} \right) - 5\gamma_2 \left(\sum_{\ell=-i,-j} \tau_{\ell\ell} \right) \quad (4.3)$$

This equation has a relatively simple intuitive interpretation. It is qualitatively similar to equation 3.3.³ Increases in the cost of shipping from i to j will decrease the volume moved along that route: conversely, increasing the cost of shipping from i to any other

2. This derivation reveals that in the Hub-and-Spoke world it is necessary to assume that $\beta < .2$, as $\beta > .2$ produces equilibrium results which are obviously incorrect (τ_{ij} would be increasing in F_j^i). The intuition behind this result is identical to the logic in Chapter 3's footnote 1. The remainder of this chapter assumes that $\beta < .2$.

3. Many of the equations in this section have more terms than are listed here. However, the slope on these "extra" terms are so arbitrarily small (usually with 16-18 zeros before a significant digit) that they are presumably the result of solving such a large system in Mathematica. For brevity the equations in this chapter omit any term with a slope less than e^{-10} , assuming that these terms are computing errors. These terms are carried through in the equilibrium derivations and do not impact the results.

nation diverts trade towards j . Increasing the prices that *other* firms have to pay to ship to j decreases the volume of products shipped to j , increasing prices in j . Finally, driving up any shipping price that isn't connected to either i or j will divert trade towards j , leading to a decrease in prices in j .

Solving the above system for shipping prices generates inverse demand curves. Letting Y denote the set of nations which are not i or j , the inverse demand curve for shipping prices between i and j is given by:

$$\tau_{ij} = -2\mu_1 F_j^i + \mu_1 (T_i - \sum_{k=Y} F_k^i) + 2\mu_2 F_i^j + \mu_2 (\sum_{k=Y} F_k^j + \sum_{k=Y} F_i^k - T_j - \sum_{k=Y} F_j^k) \quad (4.4)$$

were the μ s are positive parameters which are functions of β . This equation has a fairly intuitive interpretation. Increasing F_j^i , all else equal, can only be supported by lower shipping prices. Higher T_i increases the amount firms in i want to ship to all locations, while increases in the amount i ships to any nation besides j decreases the amount left to ship to j . Higher trade volume from j to i simultaneously drives prices down in i and drives prices up in j , drawing trade towards j . Higher shipping volumes out of j or into i both have similar effects on prices in each nation. Conversely, higher output in j or shipping volumes into j , all else equal, decreases prices in j .

As in section 3.2.3, when necessary this chapter allows for variant demand by including a D_j shock term in equation 4.2. As in the previous chapter, these terms will be suppressed in the following sections for brevity, as they have precisely the intuitively expected effects on trade volumes and prices.

4.1.2 Shipping Firms

In the hub-and-spoke system I dispense with the assumption that every nation has a single shipping firm, as it would leave a number of shipping firms in with access to only one route. Instead, shipping firms will now be summarized by which routes they have access too: a shipping firm might have access to every route (representing a large global firm) or might be limited to a smaller subset of routes by practical limitations

or market size. Otherwise, the entry and production decisions of the shipping firms work in the manner presented in chapter 3 with two notable exceptions.

First, shipping firms can only move goods between ports i and j if they operate along *every* route between those ports. For example, this means that a firm that did not operate on the route between a-d could not carry output from c to e, even if it operated along the a-c and d-e routes.

Second, longer trips are more expensive; specifically, I assume that the cost of a trip is equal to the number of steps in the trip times $C[Q_{ij}^p]$, which is now a function which represents the cost of producing a one-step voyage. So, for example, $C[Q_{cd}^p]$ (a two step trip) is equal to twice $C[Q_{ed}^p]$ (a one step trip).

Letting O denote the set of routes a shipping firm can ship output along given their entry choices, each shipping firm's profits are given by:

$$\sum_{j,i \in O} (\tau_{ij}^k Q_{ij}^i - C[Q_{ij}^k] Q_{ij}^k) \quad (4.5)$$

To illustrate the intuition behind shipping firm decisions in this model, assume there are two shipping firms, both of which can and do operate on every route (effectively the simplest possible version of this model). These firms' optimal quantities shipped between each nation would be given by:

$$Q_{ij}^* = -\psi_1 \sigma + \psi_2 T_i - \psi_2 T_j + \bar{\psi}_3 \bar{T}_g \quad (4.6)$$

were $\bar{\psi}_3$ and \bar{T}_g are 4x1 vectors of positive scalars and the non i or j output levels respectively. The exact magnitudes for the ψ terms vary depending on whether i or j are hubs or spokes and on how far away the nations are from each other, but the signs of the ψ s do not. These terms vary in an intuitively appealing way: trade is larger between immediate neighbors, larger for hub nations who are at the heart of the system, and decreases rapidly with distance, with extremely low trade volumes between spoke nations on opposite sides of the ocean. Note that none of the above derivations

are dependent on the assumption of there being only two shipping firms; re-calculating these equations with three or four identical “large” firms produces qualitatively similar results. Given this qualitative similarity, to avoid complexity the remainder of this chapter presumes there are only two shipping firms (denoted 1 and 2) which have access to every route in the world.

4.2 Hub-and-Spoke Baseline Outcomes

This section derives baseline equilibrium results for shipping firm entry and trade volumes for two simulations of the hub-and-spoke world. Section 4.3 examines how the formation of shipping alliances impacts these equilibrium outcomes.

In the hub-and-spoke world shipping firms face exactly the same entrance decision: entry incurs a fixed cost, ξ , which the shipping firm must pay before the level of output in each nation is determined. In the hub-and-spoke world these decisions can have significant economic impacts, as firm entry decisions will determine whether or not trade can even occur between many nations. Presumably any outcome which leaves some nation-pairs unconnected represents a substantial loss of utility for the abandoned nation(s), decreasing their trade volumes and leaving their consumers with a less heterogeneous mix of available consumption goods.

4.2.1 Hub-and-Spoke Symmetrical World

To establish baseline results this section analyzes the simplest possible version of the hub-and-spoke world, a simulation with complete symmetry. Specifically, this section uses the following simulation:

$$E[T_A] = E[T_B] = E[T_C] = E[T_D] = E[T_E] = E[T_F] = 10$$

$$\beta = .15$$

$$C[Q_{ij}^k] = 5 + 5Q_{ij}^k$$

Even in this simple world with only two shipping firms the set of potential entry outcomes is enormous (specifically there are 1,024 unique entry combinations). It is thus necessary to approach the process of determining entry choices in a highly stylized manner. The high degree of symmetry in this simulation and the fact that some routes are clearly more desirable allows for a relatively simple algorithmic approach to finding equilibrium results.

I begin by assuming that each firm will operate along route a-d (the route linking the hubs); the problem is only interesting if some level of entry is justified and if a firm is going to operate on only one route the logical starting place is the route which links the two hubs and would thus allow each firm the highest number of new routes to expand into. Given this initial distribution it is relatively simple to determine which route entrances are profit enhancing; these derivations reveal that the optimal firm entry decisions are to enter routes by “spreading out” along one side of the ocean.

For example, assume each shipping firm enters a route on one side of the ocean; because of symmetry the exact routes are arbitrary, but for argument’s sake assume that firm 1 entered route a-b and firm 2 entered route d-e. This entrance is strictly profit enhancing and given that entrance it is also strictly profit enhancing for each firm to enter the other route on that side of the ocean (a-c for firm 1, d-f for firm 2). Entry costs which are high enough to prevent these entrances ($\xi > 12.67$) would lead to shipping firms shutting down entirely. That is, for any plausible entry cost value the equilibrium will at least involve each shipping firm operating on the set of routes on one side of the ocean.

The only remaining question is whether or not each firm can profitably “cross” the ocean by entering one of the routes on the opposite side of the ocean. This will occur if $\xi < 8.3$, in which case the entering firm will also begin operating on the other route on that side of the ocean as well; these entrances will cause the second firm to enter all remaining routes (leading to both firms operating on all routes). This sort of “bunched entry” is quite logical in the hub-and-spoke system; once a shipping firm is operating on one side of the ocean the benefit from expanding along that branch

of the world is relatively high, since the distances and thus shipping costs involved are relatively small. For example, if a firm entered the d-e route then the return from entering the d-f route substantially increases, as the shipping firm could then transport goods from e-f, which are relatively close. Similar logic explains why, even if a firm will not expand to the other side of the ocean, that firm would not withdraw from the hub-route; the hub in the “other” half of the world is relatively close both to “their” hub and to the spokes that firm operates upon.

There is thus a large range of plausible ξ values for which the equilibrium results have the ocean as an impassible barrier: specifically, for $\xi \in (8.3, 12.67)$ there are no connections between the spoke routes on either side of the ocean. This is an extremely negative outcome, as it significantly decreases trade volume and deprives consumers in the non-hub nations of products from one third of the producers in the world, leading to lower product diversity and therefore lower utility. In this situation, referred to in later sections as the “divided” world, overall trade volumes are only about 17% of global output. If entry costs are relatively low ($\xi \leq 8.3$), then the equilibrium results will have all nations connected, leading to trade volumes which are both more heterogeneous and higher, around 24% of global output.

Moving from global results to results for individual nations, hub nations are (naturally) centers of trade; in the divided world they export about 27% of their output. Opening trade has relatively little effect on their trade volumes; their trade jumps to about 31% of their output as the larger volume of global trade depresses the return from shipping to the now more competitive spoke nations. Shipping prices to and from hub nations are relatively low and do not increase much in the divided world, as it is impossible to avoid shipping through these hubs.

Entry decisions have enormous impacts on spoke nations; in the divided world spoke nations export only 13% of their output due to high prices in the home market and low access to foreign markets. However, if entry costs are low these nations export about 21% of their output and face lower prices in the home market. Shipping prices are also much higher for spoke nations and are substantially increased in the divided

world; the cost of shipping from one spoke to the other on the same side of the ocean, for example, is 12 percentage points higher in the divided world.

4.2.2 Hub-and-Spoke Symmetrical Non-Simulated Results

A more lightly simulated version of section 4.2.1 would involve the following set of parameters:

$$E[T_A] = E[T_B] = E[T_C] = E[T_D] = E[T_E] = E[T_F] = T^*$$

$$\beta = .15$$

The equilibrium results for this set of parameters are quantitatively identical to the results in section 3.4.2. For any given set of parameters each firm's profit function takes the form:

$$\Pi = A_1 - \text{Entry Costs} - A_2 T^* + A_3 (T^*)^2$$

As with the results in section 3.4.2, all else equal, own-firm entry causes each term in this equation to increase in absolute value, while entry by the other firm causes each term to decrease in absolute value. These effects weaken as each firm expands, however; once each firm is established on its own side of the ocean further entry by either firm has relatively small effects due to the cost barriers faced when transporting cargo over wider distances. These results are thus essentially an extension of the results in 3.4.2, qualitatively similar in all practical respects, albeit revealing the rapidly diminishing impact of expansion on more far-flung routes.

It is also possible to derive the ξ threshold which separates divided and universal entry using these non-simulated parameters. The resulting equations are lengthy if left fully parametrized, but do confirm the basic conclusions of section 4.2.1 over a range of plausible parameter values. This simulation has two relatively stable equilibrium states; either both firms operate on one (arbitrarily selected) side of the ocean or both firms operate on all routes.

4.2.3 Producer-Consumer World

The assumption of strict symmetry between nations, which implies that nations trade only due to differences in tastes rather than differences in production and consumption, is not a plausible representation of the modern trading system. The final simulation this theoretical analysis considers is a version of the world which relaxes this assumption in a way that captures the essence of many current hub-and-spoke systems. Consider the following simulation:⁴

$$E[T_B] = E[T_C] = 90$$

$$E[T_A] = E[T_D] = 60$$

$$E[T_E] = E[T_F] = 30$$

$$D_A = D_D = 2.5$$

$$D_E = D_F = 5$$

$$\beta = .15$$

$$C[Q_{ij}^k] = 5 + 5 * Q_{ij}^k$$

This is a “producer-consumer world,” in which one set of ports (here B and C) are producers with high outputs but relatively small levels of domestic demand, while another set of ports (here E and F) are consumers with relatively low domestic output but high income and demand levels. This simulation assumes the ocean separates these two sets of nations to focus on the more interesting case.⁵ A and D are “middle” ports, with moderately high levels of both output and demand, representing the fact that hub

4. In this simulation it was necessary to “scale up” the T values to avoid negative trade flows from the consumer to the producer nations. Thus, it is not possible to numerically compare the entry cost figures derived in this section with results in previous sections, but the general conclusions about shipping and alliance effects on trade are equally valid. It is best to think of these results in terms of “high” vs “low” entry costs rather than in terms of the specific numbers, as the vast expansion in global output creates considerably higher profit levels for all possible shipping firm decisions.

5. In a world with one producer and one consumer on each side of the ocean it is almost certain that the overwhelming majority of trade would occur on each side of the ocean and it is thus unlikely that shipping firms or alliances would have any significant effects on trade flows.

ports are generally larger cities that companies use as staging grounds to reach more remote areas.

If $\xi > 1059$ then it is not profitable to have each shipping firm exclusively carry material from one producer economy to one consumer economy, for example having firm 1 operate along b-e and firm 2 operate along c-to-f. That outcome is implausible, so I begin by assuming that ξ is sufficiently small that at the least each firm will operate along each of those cross oceanic routes.

If $\xi > 843$ then this divided situation (with each shipping firm operating along a single producer-consumer linking route) is the equilibrium outcome. Technically, each firm could unilaterally profitably deviate by entering the other producer-consumer pair given these entry choices; however, doing so will induce the other firm to deviate in the same manner. If $\xi > 843$ then each firm operating on all routes generates negative profits, causing each firm to begin withdrawing from routes. Thus, the only outcome from deviating is either negative profit or a constant disequilibrium state; given the implicit belief in this analysis that shipping firms have a preference against uncertainty it seems reasonable to assume they will instead choose to not deviate in this situation. There are thus two plausible equilibrium states; if $\xi > 843$ the world is divided by entry costs into two producer-consumer pairs, whereas if $\xi < 843$ both shipping firms operate along all routes.

As might be expected, trade volumes are extremely high in this world. If shipping firms operate along all routes 36% of world output is exported. On a nation-by-nation basis, the hub nations export over 40% of their output, while the producer nations ship nearly 35% and the consumer nations export only about 25%. Shipping prices and volumes are both extremely unbalanced; trade flows towards the consumer nations, with much higher shipping costs in that direction, while relatively little flows to the producer nations, with consequently relatively cheap shipping in that direction.

High entry costs have a dramatic effect on the trade system; in a “divided” world total trade volume decreases to only 23% of world output and shipping costs increase dramatically, especially for shipping goods to each consumer nation. Thus,

the equilibrium results in this situation are qualitatively similar to the results in the triangular world, albeit richer. High entry costs can create situations in which profitable trades, in this case highly profitable trade between producer and consumer nations, do not occur due to the nature of the shipping sector.

4.3 Shipping Alliances in the Hub-and-Spoke World

The final section of this theoretical research analyzes how shipping alliances impact trade flows in this more realistic depiction of the international trading system. The hub-and-spoke world requires a more careful definition of the way in which alliances interact with individual shipping firm output decisions. In the triangular world there was no need to consider how alliances intersected with the ability to carry cargo because there was no routing; carrying cargo to one port only required entrance along that specific route. In this larger system, however, the intersection of entry choices and alliances become more pertinent; for example, if two firms establish an alliance to carry cargo from b-e, does the alliance also operate along every adjoining route? Does the alliance carry all cargo along all routes between b-e or restrict itself to carrying that specific pair's cargo?

I assume that alliances are formed for connected sets of ports. That is, if two firms form an alliance between any two ports that alliance takes on all traffic that flows directly between the ports on its route. So an alliance that formed to carry cargo from b-e would also carry all of its members' output along all connecting routes (so the alliance would operate along all connections between ports a, b, d, and e). Firms continue to compete normally on all other routes and can use the alliance routes for connection purposes, so a firm in the hypothetical "b-e alliance" could still carry cargo along b-c as long as they entered on the a-c route.

Shipping firms continue to split entry costs and alliance profits in even shares. Thus alliances become progressively more valuable to firms over longer routes; an alliance along a-d would result in a reduction of entry costs of $.5\xi$, while an alliance along b-e would result in a reduction of entry costs of 1.5ξ . Longer alliances allow

firms to avoid more entry costs but exposes them to a more severe competitive threat to their direct operations as the alliance becomes stronger and thus has an increasingly large impact on world prices.

In the hub-and-spoke world determining equilibrium alliance formation decisions is accomplished by examining the shipping profit implications of “types” of alliances. A “type” of alliance is an alliance which links a specific type of ports, for example hub-to-hub (a-to-d) or spoke-to-spoke (d-to-e) to determine which general alliance forms maximizes profits. This makes it feasible to narrow the set of potential alliances down to a tractably small number of options (as the specific nations involved in the alliance are not relevant for the alliance’s effect on profit levels).

The following sections conclude the theoretical research by analyzing how the introduction of shipping alliances impact the equilibrium results presented in section 4.2.

4.3.1 Alliances in the Symmetrical World

This section and the following section analyze how alliance formation impacts the equilibrium results presented in section 4.2.1. This simulation has two plausible outcomes depending on the magnitude of entry costs; either both firms operate on every route or each firm operates on one side of the ocean. This section analyzes how alliance formation impacts the first outcome (the case when entry costs are relatively low); the following section analyzes how alliances impact the second outcome.

Alliances in the hub-and-spoke world function in a manner similar to alliances in the triangular world. To illustrate this point, it is helpful to note that when all parameters are simulated then for each possible alliance configuration equilibrium firm profits can be expressed as

$$\Pi = K_1 - K_2\xi$$

where K_1 is the base profit and K_2 represents the entry costs associated with the

firm's entry choices. Entering into an alliance has two impacts on this function; K_1 will decrease, as each firm must face a higher level of global competition, while K_2 will decrease as firms are able to split entry costs for the alliance routes. These effects are stronger in absolute value for longer alliances; for example, an alliance between a-b has a relatively small impact on K_1 and only reduces K_2 from 5 to 4.5. However, an alliance between a-e substantially decreases K_1 and decreases K_2 from 5 to 3.5. Alliances are more attractive if entry costs are high relative to output volumes and longer alliances are more attractive as entry costs increase.

Comparing the profit equations for each type of alliance and assuming that a grand alliance (in which the alliance operates on every route) is infeasible, there are three potential alliance equilibria in the low-entry cost situation: no alliances if $\xi < 2.45$, a hub-to-hub alliance if $\xi \in (2.6, 2.774)$ and an alliance linking a spoke on one side of the ocean to a spoke on the other side of the ocean if $\xi \in (2.774, 8.4)$. The second result is unstable, as only a thin range of ξ s supports it (even minor uncertainty about the value of ξ would prevent this equilibrium from being feasible). A spoke-to-spoke alliance when faced with moderate entry costs is entirely plausible, however; because trade volumes between these spokes are thin, the firms are not sacrificing substantial trade volumes by forming this alliance, allowing them to avoid substantial entry costs while preserving the ability to ship between all ports.

The above equilibrium derivation explicitly ignored the possibility of a "grand alliance," in which the two shipping firms form an alliance on all routes and effectively become one large firm. Under this simulation, a grand alliance is the optimal alliance choice as long as $\xi > 2.45$ and if $\xi < 2.45$ no alliances are justified. Thus, a grand alliance is a strictly dominant strategy. In general, a grand alliance will be a dominant strategy under virtually every simulation, as it removes the trade-off between entry costs and fiercer competition, negating the dilemma a firm faces when forming alliances. A grand alliance allows firms to achieve monopoly profits with no

corresponding sacrifice, largely robbing the analysis of anything interesting to study.⁶ Much of this analysis thus assumes that in many cases a grand alliance is infeasible for non-economic reasons such as regulatory barriers or practical issues with large scale co-ordination. These results will therefore typically present both the grand alliance equilibrium results and the equilibrium results if a grand alliance is not feasible, despite the fact that the grand alliance is usually optimal.

These results are qualitatively similar to the results in the triangular world for trade volumes; the introduction of alliances is a net negative. A spoke-to-spoke alliance decreases global trade volume from 24% of global output to about 22% of global output while leading to slightly higher prices. Furthermore, alliance formation distorts the distribution of international trade; as the alliance operates as a monopoly along its chosen route it internalizes the effect that its quantity choices on those routes has on its profit on all other routes. This causes the alliance to decrease the volume it ships from alliance ports to other alliance ports. For example, if the alliance links b-e then the trade between b-d and d-e will decrease. However, that output still exists and is frequently shifted towards non-alliance ports, leading to an increase in trade from alliance ports to non-alliance ports; in effect the alliance diverts trade away from itself. Shipping prices are distorted in a similar way; they increase across the board but increase much less to and from non-alliance ports.

A grand alliance has even more catastrophic effects on trade, lowering trade volumes from 24% of global output to 16%, while preserving fairly similar ratios of port-type-to-port-type trade flows. Shipping prices increase across the board, especially between ports that are relatively close to one another as the grand alliance flexes its considerable market power to maximize its profits. If shipping firms would not abandon routes in the absence of alliance formation then alliances are a net negative for trade, utilizing market power with no corresponding increase in trade connectivity.

6. Although, as section 4.3.4 establishes, a grand alliance does not always have a negative impact on global welfare.

4.3.2 Alliances in the Divided Symmetrical World

This section analyzes how shipping alliances impact the equilibrium results in a symmetrical world where entry costs are high ($\xi \in (8.3, 12.67)$). In this case, in the absence of alliance formation each shipping firms will only operate on the hub route and the spokes on one side of the ocean; each spoke nation is separated from the spoke nations on the other side of the ocean. In this scenario alliances present a far more interesting alternative, both because they are much more likely to be feasible (as the principal benefit of alliances is entry cost avoidance) and because it is much more likely that alliances are welfare enhancing, as they might allow trade between previously disjoint nations.

From a conceptual standpoint, however, alliances in this divided situation present a complication; *which* routes the alliance operates on are now relevant for each firms' decisions. When both firms operated on every route there was no need to specify where the alliance formed, because the newly formed alliance would always displace both firms. In the divided world, however, alliances forming on one side of the ocean represent a much heavier competitive threat to the shipping firm operating on that side of the ocean, as it will directly displace that firm's operations.

To resolve this issue, I presume that in this situation each shipping firm assigns a 50% weight to the profit they receive if they end up "directly" competing with the alliance (i.e., the alliance operates on their side of the ocean) and a 50% weight to the profit they receive if they're separated from the alliance's competition (i.e., the alliance operates on the other side of the ocean). This could represent the firms randomizing which routes the alliance operates on or the firms alternating period-by-period. There is not a need to specify the precise mechanism, as all will have the same ultimate effect on equilibrium outcomes.

Under this system of alliance profit weighting it may seem like alliances do not actually save firms much or even any entry costs. In the baseline results firms pay entry costs of 3ξ , while in many kinds of alliances the firms still pay $2.5-3\xi$, as whenever the alliance takes over a route each firm views themselves as having a 50% chance of having

to pay half the resulting entry cost for a route on which they did not previously operate. The alliance can only directly save costs when it operates on a route upon which both firms were previously operating, which in this case is only the route which links the two hubs.

However, what alliances are accomplishing in this situation is allowing firms to trade more widely while not increasing their entry costs. For example, imagine that an alliance is formed between a-f. While the immediate decrease in entry costs is quite small (3 to 2.5), it is now possible for trade to occur between port f and ports b and c, as the alliance allows the shipping firm that operates on the other side of the ocean to access those ports. That entry would previously have cost 4ξ , which is why it does not occur when entry costs are high. Alliances are saving on what entry costs *would* have been, allowing firms to reach a wider variety of nations without paying higher entry costs.

Whether or not an alliance is viable under this simulation depends on whether the alliance contains the hub-to-hub route. Alliances which do not contain this route, such as an alliance that links e-f, do not reduce entry costs. None of these alliances are profit enhancing under this simulation; the losses from more fierce competition are greater than the gains from wider access.⁷ This is due to the fact that many of the new routes gained from the alliance formation are far apart and consequently face much higher transportation costs.

Conversely, under this simulation, *every* alliance which contains the hub-to-hub route and at least one other route is profit enhancing (including a grand alliance). All of these alliances are viable because the ability to gain access to new routes counteracts the new competitive pressure; while in every case shipping firm expected profit falls slightly it does not fall much, and the difference is far outweighed by the ability to avoid even a small amount of entry costs (for these alliances $\frac{\xi}{2}$). The ability to reach new

7. This non-viable category also includes a pure hub-to-hub alliance which grants no new access to routes and thus does not increase profits.

markets while avoiding entry costs can outweigh any competition issues from alliance formation.

Longer alliances are preferred in this situation; the profit maximizing alliances are an alliance which links a spoke to a spoke on the other side of the ocean and a grand alliance which links all ports. The grand alliance is the numerical equilibrium, but given the potential regulatory issues that this specific alliance will face it is worthwhile to consider how both kinds of alliances impact trade. The smaller alliance is directly trade enhancing; after alliance formation global trade is both slightly larger, by about .3 of a percentage point, and much more heterogeneous as there are now only two ports without a direct link. Shipping prices are, as before, distorted in the direction of the alliance, but are not otherwise much changed. The grand alliance is more complex; it decreases global trade volume by about 1.5 percentage points and increases all shipping prices, but also strongly increases product heterogeneity in all ports. Its effect on welfare will thus depend on the relative utility weight of trade variety versus trade volume.

Still, it seems intuitively appealing to conclude that alliance formation is welfare enhancing in the high-entry cost case. It is obviously welfare enhancing if grand alliances are illegal, as the smaller alliance increases trade volumes and product variety. If one places even moderate utility weight on output variety, then the grand alliance is also welfare enhancing. These results are largely similar to the results in 3.5; when the nature of the shipping industry would cause shipping firms to fail to service some routes or only serve them intermittently alliances are trade enhancing.

4.3.3 Alliances in the Producer-Consumer World

The final two sections of the theoretical research analyze how alliance formations impacts the equilibrium outcome in the producer-consumer world introduced in section 4.2.3. This section analyzes the economic effects of alliances when entry costs are relatively low ($\xi < 843$), in which case shipping firms operate on all routes. Section

4.3.4 analyzes how shipping alliances impact the equilibrium outcome when entry costs are relatively high.

To restrict the analysis to alliances which are plausible, I assume that any alliance involving a route which covers a consumer nation but *not* a producer nation is infeasible, as the shipping firms would then be giving up the most valuable route they operate upon for no obvious benefit. Thus, the following analysis only consider alliances that either link producer or hub nations to other producer or hub nations, or producer to consumer nations, vastly reducing the set of potential equilibria.

Comparing the profit from forming alliances between different nations reveals a clear trend; alliance formation generates much higher profits when the alliance is on a route that includes a producing nation. This has a simple intuitive interpretation; alliances allow the shipping firms to continue moving goods from the producing nation while paying lower entry costs. This is highly beneficial, as carrying output *from* producing nations is considerably more valuable than carrying output *to* producing nations, as the domestic market in the producing nation is small. Alliances offer a cost effective method to transport this output and the loss of the producer nation's domestic markets is not a significant loss to the firms' profits.

Based on the expected profit functions from alliance formation, there are four equilibrium alliances depending on entry costs. If $\xi < 138$ (the lowest entry cost case), no alliances form. If $\xi \in (138, 207)$ a hub-to-hub alliance forms to preserve route access while saving some of the slightly higher entry costs. If $\xi > 207$ then an alliance forms which links one producer nation with the two consumer nations, leaving both shipping firms operating on the route linking the final producer nation to its hub, and if $\xi > 366$ a grand alliance will form (if allowed).

The economic impact of these alliances are qualitatively similar to the economic impact of alliances in other situations where all firms were initially operating on all routes. Longer and more powerful alliances lead to progressively lower trade volumes as the alliances utilize more and more market power. Shipping prices change in the expected directions, increasing universally but growing much more strongly for ports

in the alliance, diverting trade towards the non-alliance routes. Mirroring all previous results when shipping firms would otherwise serve all routes there are no trade benefits from alliance formation.

4.3.4 Alliances in the Divided Producer-Consumer World

To conclude the theoretical research this section examines how alliance formation impacts the equilibrium of the producer-consumer world when entry costs are relatively high. This is a case that is of special interest, as both features of this depiction (relatively high entry costs and geographically separated producers and consumers) capture the essence of the modern trading system. In the absence of alliance formation, in equilibrium each firm operates along one route linking a producer nation to a consumer nation, with neither firm able to profitably deviate from that divided equilibrium. Alliances could significantly impact this equilibrium, as the high level of entry costs would make the prospect of forming an alliance very beneficial to firms, whereas the potential for the alliance to expand the number of connected ports suggests that alliances may be welfare enhancing. In this divided world, the specific routes an alliance operates on matter for firm decision making; thus, this section relies on the same alliance profit weighting established in section 4.3.2, assuming each firm places a 50% weight on the possibility that the alliance will operate on their routes vs. their rival's routes.

Under this simulation, alliance formation is a dominant strategy; regardless of the specific value of entry costs alliance formation dominates the non-alliance outcome in expected profit terms, meaning that an alliance *will* be formed in the divided world. Specifically, regardless of entry costs, an alliance that links the two producer nations with one consumer nation or a grand alliance are dominant strategies, with the grand alliance as the numerically dominant strategy. Forming these alliances allows the firms to access routes they previously could not profitability reach, allowing them to attain higher profit levels even with the higher level of competition.

Under this simulation, both types of alliances are trade enhancing; after alliance formation global trade volumes are slightly higher for the grand alliance, were global trade volume increases by about .6 of a percentage point, and dramatically higher for the smaller alliance, were global trade volume increases by about 2.7 percentage points. Shipping prices under both types of alliances increase for closer ports but decrease for longer trips and are slightly higher for the grand alliance, but the net effect is virtually neutral. More importantly, though, both types of alliances vastly increase product variety in every nation without substantially increasing prices.

Alliances are a clear positive to worldwide trade in this set up, leading to higher trade volumes regardless of whether or not there are regulatory barriers to forming a grand alliance. This is an important result, as this is the specification which most strongly mirrors the modern global trading system; the fact that alliances are a net positive in this simulation is a strongly pro-alliance result.

4.3.5 Theoretical Results from the Hub-and-Spoke World

Many of the results in the hub-and-spoke world are qualitatively similar to the theoretical results from the triangular world presented in section 3.6. In both configurations of the world higher entry costs depress trade and alliances are harmful to trade when entry costs are low and beneficial to trade when entry costs are high. Rather than restate those conclusions, therefore, this section states the unique conclusions that can be drawn from the hub-and-spoke world:

1. **When Entry Costs are High Trade Will be Unbalanced:** Due to the small number of ports this point did not emerge in the triangular world. In the hub-and-spoke world, route abandonment has significant effects on the availability of different goods as well as the sheer volume of trade. High entry costs lead to more homogeneous trade and thus lower consumer welfare.
2. **Alliances have Larger Impacts on Spoke Nations:** In general, throughout these results the impact of alliance formation (positive or negative) is much larger on spoke nations, as the hub nations are rarely abandoned. Alliances should thus have a more dramatic impact on smaller, more isolated ports.

3. **Alliances are More Likely on Long Routes;** Throughout these results the optimal alliances are longer alliances that link a string of ports; it is rarely worthwhile to have an alliance along only one route, especially when ports are non-symmetrical. This is a well-established empirical reality in the actual shipping industry, in which alliances are much better at rationalizing output over long, multi-port routes.
4. **Alliances are More Likely Coming From a Producer Nation:** As shown in sections 4.3.3 and 4.3.4, alliances are much more likely to form when they include a route leading from a primarily exporting nation rather than from a primarily importing nation, as those are the routes on which shipping firms most want to maximize their productivity.

4.4 Theoretical Conclusion

While there a number of ways this theoretical research could be further expanded, sections 3.6 and 4.3.5 paint a clear picture for how alliances impact the trading system. In terms of the alliances themselves, these results predict that shipping alliances are more likely between similar firms, are more likely to form on longer routes, and are more likely to form on routes which include major exporting nations. All of these predictions are well established empirical realities; these results are entirely consistent with the most visible features of the modern liner shipping alliance system.

In terms of the economic consequences of shipping alliances, these results suggest that the economic impact of liner shipping alliances depends on how shipping firms would behave in the absence of alliance formation. Shipping alliances are positive in situations when the realities of the shipping sector, especially high entry costs, would prevent the free flow of trade between all nations due to shipping firms not adequately servicing all routes. In those cases, even though shipping alliances utilize market power the resulting gains from more widespread trade outweigh the market power cost. Conversely, when shipping firms would serve all routes in the absence of alliances then alliance formation is a source of market power which depresses trade.

Despite the ambiguity in these results, I argue that this outcome supports the concept that shipping alliances are economically beneficial. While data on entry costs are unavailable, it is generally accepted that entry costs in the liner shipping sector

are substantial and the steadily increasing size of the average ship implies that entry costs become larger each year. The “high entry costs” versions of these results are thus the more logically plausible results, although data to formally test this proposition are not available. It is thus significant that the “high entry cost” results universally suggest that alliances are beneficial to trade, as these situations are a more plausible description of the modern trading system.

Furthermore, the way shipping alliances are represented in this theoretical research is quite harsh, effectively assuming that alliances function as cartels. In reality the anti-trust scrutiny that such behavior would draw and the potential deviations it would encourage amongst the alliance’s member firms implies that such strict cartel behavior would be unlikely to be effective. To the extent that this representation of shipping alliances is incorrect, then, it is incorrect in a way that makes shipping alliances appear more harmful to trade. The fact that liner shipping alliances are still likely to be trade enhancing under this set of assumptions suggests that they are even more likely to be beneficial under more plausible “gentle” assumptions. In short while this research cannot support a definitive conclusion about the economic impact of shipping alliances, I believe the bulk of this theoretical research suggests that liner shipping alliances are beneficial to the trading system.

Chapter 5

EMPIRICAL SPECIFICATION AND DATA

5.1 Empirical Introduction

This chapter describes the empirical approach and data used to test the theoretical conclusions presented in Chapters 3 and 4. While data on the volume and distribution of trade have always been available, leading to the empirical trade literature mentioned in Chapter 2, information on shipping prices and the behavior of specific shipping firms was either not available or only available in an extremely limited format. There are no historical data for the worldwide distribution of shipping capacity and only a few shipping price indexes which are based on data from firms which operated in specific European nations (Hummels 1999). Due to these severe data constraints empirical trade research has largely avoided shipping issues, instead focusing on more quantifiable concerns like trade barriers.

In the last fifteen years, however, as the shipping sector has risen in importance in the globalized economy, governments and private firms have begun to gather more detailed data on the activities of liner shipping firms. GPS tracking, combined with rapid communication between ports, has made it technologically feasible to track exact ship positions. As a result, higher quality liner shipping data are available for more recent periods. Sufficient data on market concentration in liner shipping now exist to examine the connection between shipping alliances and trade. The available data on the geographic distribution of liner shipping capacity are not complete enough to directly test the model in Chapter 4. Rather, the empirical analysis presented here focuses on how changes in alliance market share have impacted bilateral trade flows. Thus, the results in Chapter 7 and the results in Chapters 3 and 4 are complementary -both examine the same question- but are not directly related.

This analysis uses a unique data set with a geographic and temporal coverage not available in previous research and the empirical results shed new light on the connection between the liner shipping industry and the international trade system. This chapter presents the empirical approach used to examine the link between the liner shipping sector and international trade and describes the data. Results from these empirical tests are presented in Chapter 7.

5.2 Empirical Specification

5.2.1 Gravity Models

This research used a gravity model as an empirical specification to examine the connection between liner shipping activity and trade flows. The gravity model assumes a functional form for bilateral trade flows that is similar to the Newtonian gravity model (Anderson 2011). Formally, most gravity models assume that the value of bilateral trade between nation i and nation j in time period t , denoted Y_{ijt} , is given by the function:

$$Y_{ijt} = \frac{y_{jt}^A y_{it}^M}{d_{ij}^k} \exp(\boldsymbol{\lambda} \mathbf{L}_{ijt}) \quad (5.1)$$

where the y s are output in each nation, d_{ij} is the distance between nations i and j , \mathbf{L}_{ijt} is a vector of “linkages,” or non-distance or output factors which can influence bilateral trade between i and j , and A, M, k , and the components of $\boldsymbol{\lambda}$ are parameters to be estimated. The connection between this equation and the Newtonian gravity model becomes explicit if $A = M = 1, k = 2$, and $\boldsymbol{\lambda} = \mathbf{0}$. The traditional empirical specification of the gravity model is generated by taking the natural logarithm of equation 5.1 and adding an ad-hoc error term and intercept, generating the following equation:

$$\ln(Y_{ijt}) = \beta_0 + A \ln(y_{jt}) + M \ln(y_{it}) - k \ln(d_{ij}) + \mathbf{L}_{ijt} \boldsymbol{\lambda} + \epsilon_{ijt} \quad (5.2)$$

A common utilized variation on equation 5.2 adds fixed effects, usually for time and exporter-importer pair (Mátyás 1997, 1998). Adding fixed effects to equation 5.2

yields the following empirical specification:

$$\ln(Y_{ijt}) = \beta_0 + D_{ij} + D_t + A\ln(y_{jt}) + M\ln(y_{it}) - k\ln(d_{ij}) + \mathbf{L}_{ijt}\boldsymbol{\lambda} + \epsilon_{ijt} \quad (5.3)$$

where D_{ij} and D_t are, respectively, the exporter-importer and time fixed effects. The inclusion of exporter-importer fixed effects is in line with recent advances in the econometrics of gravity models. Recent gravity model research has focused on establishing a theoretical foundation for the historically largely atheoretical gravity model. Deriving gravity models from standard trade micro-foundations generates gravity equations in which trade is dependent on *relative* prices as well as GDP and distance (Anderson and Wincoop 2003; Anderson and Yotov 2010). Much of this research has focused on estimating “multilateral price resistance terms,” which measure the relative gap between prices in each nation and average worldwide prices, to account for the empirical impacts of price differentials. Since these terms do not vary by time or exporter-importer pair, however, including nation-pair fixed effects accounts for their impacts, preserving unbiased estimation (Baier and Bergstrand 2007).

Gravity models that use an equation such as 5.3 as their base specification are common in the empirical trade literature, with differences coming from the specific factors included in \mathbf{L} (Disdier and Head 2008). To ensure that the empirical results are generally comparable to this literature, this research uses equation 5.3 as a core empirical specification, adding variables related to liner shipping to \mathbf{L} . Section 5.2.2 defines the liner shipping related variables used in this work before presenting the final empirical specifications.

5.2.2 Geographic Levels in Liner Shipping

There are two geographic levels at which one could measure the activities of liner shipping firms and thus liner shipping alliances. First, one could measure activity at a “route” level, directly examining how much capacity each alliance is operating between each nation-pair in the sample. Alternatively, alliance behavior could be analyzed

at the “trade” level, examining how much capacity each alliance is operating in the wider trading region that contains each nation-pair.¹ For example, on a route level the alliance behavior between the United States and Japan is the shipping capacity controlled by that alliance between the two nations; on a trade level, the alliance behavior is the total shipping capacity controlled by that alliance in the trading region between Asia and North America. Each empirical test reported in this research is estimated on both levels to ensure that results are qualitatively similar. This section explains the advantages and disadvantages of the two geographic levels and then defines the alliance capacity based variables which were used to measure alliance market share for each scale.

Intuitively, route level data seem more representative of alliance activity than trade level data, as they match alliance behavior to a specific nation-pair rather than aggregating across nation-pairs in a broader region. Beyond the advantage of more accurate measurement, route level data are more universally available than trade level data. Assigning trade-level capacity numbers is problematic for some nation-pairs in the sample; a subset of island nations in the sample trade with nations on the same continent and cannot be mapped into the standard “East-West” trades, which are *between* continents. Trade level capacity data are not available for these countries and their measured trade level capacity is zero. Route level data avoid these issues as they do not require nation-pairs to be assigned to any specific trading area. However, there are a number of reasons to potentially favor trade level data. First, data on the route-level capacity fielded by all shipping firms, as opposed to alliance controlled capacity, are not available. This limits what can be measured at the route level. It is possible to measure how much capacity each alliance operates but it is not possible to measure route level market share, as doing so requires data on the activity of non-alliance firms.

1. There are three major trades, sometimes known as the “East-West” trades; North America-Europe (Transatlantic), Europe-Asia, and Asia-North America (Transpacific). Widespread data exist for these trades, while virtually no data exist for smaller trades (such as Africa-South America) and consequently these are the trades used in this empirical work.

More importantly, it is unclear if route level data are really an accurate representation of the available capacity between any nation-pair. The modern liner industry makes heavy use of hub-and-spoke routing strategies, in which most goods are moved between larger ports and then distributed amongst nearby nations using smaller ships. This means that the specific capacity that travels between two nations can be a misleading measure of the capacity available to move goods between those nations, as a much larger amount of capacity might be available via routing through a major hub. For example, there are few direct sailings from Australia to the United States and, consequently, the amount of capacity operated between them is negligible. This is not because liner shipping firms do not carry cargo between them, however; it is instead because it is more economically practical to route goods from each nation to other southern Asian nations such as Singapore or Hong Kong and then ship those goods to their true destination from those hubs. The direct capacity between these two nations is not representative of the available capacity to transport cargo between them, a situation that is common given complex modern shipping chains. While it is possible to measure the alliance-controlled capacity directly operating between two nations, it is not clear that this number is necessarily accurate. It may well be the case that overall trade level data are more representative of actual available capacity, as shippers are able to access most of that capacity by shipping through a hub.

Rather than select a single geographic level, each empirical result in this work was estimated on both the route and trade level to ensure that the results are qualitatively similar on either level. For each test, I utilize variables measuring liner shipping activity based on the capacity data defined in section 5.4. The variable “Capacity” measures the total weekly TEUs of capacity fielded by all liner shipping firms on that

trade in that month.² This variable is scaled to the 10,000 TEU level, which is approximately the size of an average liner vessel. The resulting co-efficient could thus loosely be interpreted as the anticipated percentage effect on a nation-pair’s bilateral trade from adding a new vessel’s worth of capacity to that pair’s larger trading region.³

I define two variables to measure the extent of market domination by liner shipping alliances on the different geographic levels. On an overall trade level, “Alliance Market Share” measures the percent of total weekly TEU capacity in each trading region controlled by one of the four major alliances. On the route level “IndividualCapacity” measures the total weekly TEUs of capacity controlled by one of the four major alliances which operate on any service which connects the nation-pair being examined, scaled to the 10,000 TEU level.

Using these variables I estimated each empirical test on both scales.⁴ To estimate trade level results, I augmented equation 5.3 with trade-level capacity and alliance market share, yielding an equation of:

$$\begin{aligned} \ln(Y_{ijt}) = & \beta_0 + D_{ij} + D_t + A\ln(y_{jt}) + M\ln(y_{it}) - k\ln(d_{ij}) \\ & + \lambda_1(\text{Capacity}_{ijt}) + \lambda_2(\text{Alliance Market Share}_{ijt}) + \epsilon_{ijt} \end{aligned} \quad (5.4)$$

The resulting slope on market share can be interpreted as the effect of increasing the

2. A “twenty-foot equivalent unit” or TEU is the standard measure of capacity in the liner shipping industry. This number represents the space occupied by a standardized twenty-foot shipping container and is the generic measure of ship size in liner shipping. Rather than expressing ship size by physical dimensions, ship size is expressed as the cargo that ship can carry. For example, a ship’s size will be reported as “6,000 TEUs,” (that is, capable of carrying the equivalent of 6,000 twenty-foot containers).

3. Adding a new vessel’s *worth* of capacity will generally require more than one new vessel, as there must be sufficient ships to carry out a full service rotation. For example, if a shipping firm tried to expand their weekly capacity by 10,000 TEUs per week by adding a new service which had a seven-day rotation through six ports it would need six 10,000 TEUs ships to operate the service.

4. While every empirical test includes exporter-importer, time, language, and west coast labor strike fixed effects, the results for these fixed effects are excluded for readability throughout this dissertation. Full output tables and the underlying STATA code are available upon request. For ease of reading all trade and output data are scaled to a billion dollars, while distance data are scaled to a thousand kilometers.

percentage of the market controlled by alliances while holding capacity constant, or the impact of a larger share of the existing market coming under alliance control.

To account for the possibility that these results may be different if measured on a route level, each empirical test included a second regression which adds Individual Capacity to equation 5.4. The slope on this term can be interpreted as the effect of an alliance expanding capacity on a specific bilateral nation-pair while holding overall capacity and alliance market share constant, or the impact of an alliance choosing to focus more heavily on that specific nation-pair.⁵

Estimating equation 5.4 required data on bilateral trade, GDP in each nation, the distance between each nation, and measurements of the intensity of alliance activity between each nation. The remainder of this chapter establishes the data sources used.

5.3 Geographic Sample Selection

This section explains the selection process for the nation-pair sample included in the empirical sample. As the goal of this empirical work is an analysis of *oceanic* shipping, this nation-pair sample is restricted to the set of nations that are frequent oceanic shippers. While liner shipping almost certainly impacts the entire trading system, as shipping costs will impact distribution costs even for nations who are land-locked or have no major ports, I viewed the connection between liner shipping and “non-oceanic” nations as too tenuous to be estimated empirically. For those nations a host of other factors, notably issues arising from other transportation industries, would make attempts to quantify the specific impact of liner shipping impractical. This analysis is thus restricted to a subset of nations whom I viewed as being sufficiently reliant on oceanic trade that their bilateral trade is heavily impacted by the actions of the liner shipping industry.

This list is derived from Containerisation International’s report on the hundred largest ports in the world in 2014 (Containerisation International 2014). This report

5. The results from these route level regressions are qualitatively identical regardless of whether or not they include the market share term.

ranks ports based on the volume of cargo that passes through the port over the course of the year. Each of these ports is a significant part of the global trading system; even the smallest of them had a total yearly volume of 1.28 million containers in 2014. Any nation which contains one of these ports is engaging in significant maritime trade. Having at least one of these ports is the criterion used for whether or not a nation should be included in the sample. This generated a list of the 45 nations that collectively contain all hundred ports. Due to data constraints created by international sanctions, one of these nations (Iran) could not be used in the empirical work, leaving a final sample of 44 nations. The unit of analysis for the empirical specification is a bilateral connection between two nations, i and j . The full sample for the empirical work is thus the bilateral trading pairs among these forty-four nations. Using every single bilateral trading pair with forty-four nations would yield 1,892 exporter-importer pairs.⁶

However, using every one of these combinations would severely weaken the empirical validity of any results derived from this “full” sample. While each of these forty-four nations is a major international shipper, it is not necessarily the case that all or even a majority of their *bilateral* trade is oceanic. For some of these nation-pairs only a minor fraction of their trade is oceanic. For example, both Canada and the U.S. are significant global oceanic traders: however, in 2014 only 12% of U.S.-Canada bilateral trade was carried by *any* form of non-land based transport.⁷ The two nations’ geographical proximity ensures that the vast majority of their bilateral trade is not oceanic. Including this pair or similar pairs risks diluting the empirical validity of the sample, as bilateral trade between these sorts of pairs is unlikely to be strongly

6. For these tests a specific nation-pair represents two distinct exporter-importer combinations. The U.S. and France, for example, would represent two data points in each time period in the sample: U.S. exports to France and French exports to the U.S.

7. This number was derived from the U.S. Bureau of Transportation Services’ “North American Transborder Freight” database.

impacted by changes in the liner shipping sector. This research thus used a more restricted subset of routes in the empirical work in an effort to filter out nation-pairs whose trade is unlikely to be significantly impacted by changes in the oceanic shipping sector.

Data on the method of transportation for bilateral trade are not available for most bilateral trading pairs.⁸ As a result, I exclude from the sample nation-pairs sharing land routes on the same continent, defining Africa, Asia, Europe, the Middle East, North America, and South America as continents. For example, the sample does not include bilateral trade between Germany and Spain, as both are European, even though they do not share a land border.

I included all trading pairs for island nations, as by definition none of their trade is transported by land. Singapore and Indonesia are recorded as island nations despite their geographic proximity to Malaysia, as in both cases land transportation is commercially infeasible. Singapore is an island, but has direct links to Malaysia; however, the two bridges which link the nations are all-purpose, handling both commuter and commercial vehicles. Given Singapore's status as a maritime hub it is unlikely that much of its trade flows through the narrow set of land-transportation options available to it. Indonesia technically abuts Malaysia on the island of Borneo; however, there are no land connections to Borneo, forcing all out-bound trade to be transported using non-land based methods. I also counted South Korea as an "island," as the military situation along the 38th parallel prevents them from shipping any goods by land.

This leaves the forty-four nation sample divided into the following continent groupings which define which nation-pairs were excluded:

1. **Africa:** Morocco and South Africa (2 countries)
2. **Asia:** Bangladesh, China, India, Malaysia, Pakistan, Sri Lanka, Thailand, and Vietnam (8 countries)

8. Even the U.S. does not generally track these data for all trading partners; they were available for the U.S.-Canada only because the two nations are NAFTA partners. In general it is not feasible to directly examine the extent the primary transportation method for trade between each nation-pair.

3. **Europe:** Belgium, France, Germany, Greece, Italy, the Netherlands, Russia, and Spain (8 countries)
4. **Islands:** Australia, the Bahamas, Indonesia, Jamaica, Japan, Malta, the Philippines, Singapore, South Korea, Taiwan, and the United Kingdom (11 countries)
5. **Middle East:** Egypt, Israel, Oman, Saudi Arabia, Turkey, and the United Arab Emirates (6 countries)
6. **North America:** Canada, Mexico, Panama, and the United States (4 countries)
7. **South America:** Argentina, Brazil, Colombia, Ecuador, and Peru (5 countries)

There are some border cases (no pun intended) when attempting to group nations into “natural” continents. In particular, note that Russia is classified as European, Turkey is classified as Middle Eastern, and Pakistan is classified as Asian, due primarily to the geographic position of their major ports and roads rather than as any commentary on their politics or history. Under this criteria, there were 1,716 valid exporter-importer combinations, which compose the nation-pair sample for the remainder of the empirical work.

5.4 Alliance Capacity Data

5.4.1 Alliance Capacity Data

In the following sections I explain the source for the data used to measure the market share controlled by each major shipping alliance. These data measure the total capacity controlled by each of the major alliances for the fifty-month period from January 2011 to February 2015 for each bilateral nation-pair and major trade. These data measure the extent to which individual alliances and alliances as a group control the total available “shipping output” in these areas.

The largest historical stumbling block to empirically evaluating the liner shipping industry has been a lack of access to data on shipping output. Specifically, output in liner shipping is measured as the available capacity that each firm is operating, based on the routing pattern and speed of their current sailings. Reported output in the liner

shipping industry is actually a measure of the potential capacity that each shipping firm or alliance fields in each trading area.

Considerable theoretical work suggests that capacity is the critical decision variable for liner shipping firms. In a classic result, Kreps and Scheinkman (1983) demonstrated that when firms pre-commit to a certain level of output (which they call “capacity”) and then sell that output under Bertrand price competition, the Nash equilibrium result is equivalent to the Cournot result. Intuitively, because these “pre-sale” decisions impact all later decisions they essentially define how the firms will behave when they do face market competition. This implies that if a firm has to make significant decisions before market conditions are known, there will be a direct relationship between these decisions and the resulting firm behavior. Later research has confirmed that this result applies in many cases, notably for liner shipping in the case where the cost of “capacity” is high relative to the level of uncertainty in demand (Lepore 2012). Due to the expense and time commitment of new shipbuilding, liner firms make most major capacity decisions months in advance and it is perfectly reasonable to believe that their behavior can be accurately summarized by looking at how their capacity is arranged, with their actual volume and price decisions largely determined by those capacity decisions.

Capacity data are not, in principal, difficult to gather. Liner shipping companies announce and rigidly adhere to pre-determined sailing schedules for their ships to ensure reliable shipping. Each liner shipping company’s current market activities can be summarized by a list of these schedules, which in the industry are known as “services.” A service is a set of dedicated ships who move between all of the ports in the sailing schedule on a fixed timetable. While firms do regularly change the way they route vessels, they do so in a scheduled and announced manner, for example by declaring that one of their services is gaining another ship or will cease serving a port. Liner shipping firms do not reroute vessels to meet current demand in the flexible way that a trucking or air company might, due to the complexity and expense of operating even a small vessel. Therefore, it is possible to track shipping firm capacity by examining

each shipping firm's or alliance's list of services.

While historical data on liner shipping services are not available, during the last fifteen years several major consulting firms have rigorously tracked data on the service activities of the major liner shipping firms. I specifically derived capacity data using service data from Alphaliner (www.alphaliner.com), which tracks the activity of liner shipping firms by monitoring firm announcements and examining ships as they enter ports. Their data make it possible to track exactly how much capacity each shipping firm or alliance operates on each major trade and route and, as explained in section 5.4.2, can also be used to build a time series of this information.

Data came from Alphaliner's services database, which tracks the capacity and geographical distribution of each currently active service. Depending on the number of ships involved, ports reached, and speed each service will have an average TEUs of capacity launched from each port every week. This average TEUs of capacity per week is the measure of capacity used throughout the empirical work. Figure 5.1 presents one example of these data, a summary of a service called "CC1" operated by the G6 shipping alliance, which carries traffic from Asia to the U.S. West Coast.

Figure 5.1 shows that the CC1 service uses seven vessels which operate on a route that links Shanghai to the U.S. by way of Korea. The service launches a vessel from each port every seven days, requiring each vessel to return to each port in the chain once every 49 days. On average this service launches 6,296 TEUs of available space from each of the ports every week. The overall data set consists of a larger list of similar service data, ultimately composed of data on 131 different services which either are or were operated by one of the four major alliances on one of the three major East-West trades.⁹

While there is quite a bit of data contained in each of these service details, for the purposes of this study I collect the following information for each service. To

9. A small number of large services are called "pendulums," services whose coverage spans more than one major trade (linking, for example, the U.S.-Asia-Europe-U.S...). These pendulum services can appear in the data more than once, as they represent capacity on more than one trade.


 Alphaliner - Service data									
G6 - Far East-PSW service - CC1									
Participants	Hapag-Lloyd / NYK / OOCL / APL / MOL / HMM								
Coverage	FE / PSW								
Type	FC								
Sailling frequency	7								
Duration of rotation	49								
Ships used	7 x 6 700 teu								
Weekly capacity (teu)	6296								
Port rotation									
Shanghai (Waigaoqiao), Kwangyang, Busan, Los Angeles, Oakland, Busan, Kwangyang, Shanghai									
Comments									
Service organized in May 2014 as part of the extended G6 partnership (See news).									
> Dec 2014-Jan 2015 - Rotation stretched by one week due to congestion in USWC ports (from 6 to 7 weeks).									
© Alphaliner									
Ships deployed									
Vessel Name	Typ	Flag	DWT	TEU	TEU 14	Speed	Gear	Operator	Open date
HYUNDAI SHANGHAI	cclo	CYP	80,262	6,765		26.0	No	Hyundai M.M.	
HYUNDAI HONGKONG	cclo	CYP	80,105	6,765		26.0	No	Hyundai M.M.	
HYUNDAI TOKYO	cclo	CYP	80,059	6,765		26.0	No	Hyundai M.M.	
MOL PREMIUM	cclo	PAN	72,968	6,350	4,500	25.0	No	Mitsui-OSK L. (MOL)	(own)
HYUNDAI LONG BEACH	cclo	LBR	72,665	6,350	4,494	26.0	No	Hyundai M.M.	
HYUNDAI TACOMA	cclo	LBR	72,665	6,350	4,494	26.0	No	Hyundai M.M.	
HYUNDAI FORWARD	cc	PAN	62,450	4,728	3,194	25.2	No	Hyundai M.M.	(own)
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Figure 5.1: Service Details for CC1

illustrate, data for the CC1 service from figure 5.1 are presented in parentheses next to each item.

1. Number of ships used (7)
2. Average weekly capacity in TEUs (6,296)
3. Countries served (China, South Korea, and the United States)
4. Operating alliance (G6)
5. Which major trading region the service was operating on (Transpacific)
6. Service's start and end date if not currently operating (May 2014 and still active)

For some services it was necessary to make a judgement about exactly which trades the service was operating upon. For the overwhelming majority of cases this is straightforward, but for a small number of pendulum services it is more ambiguous.

Specifically, a small number of services are pendulums which do not touch the Atlantic Ocean, carrying cargo along a Europe-Asia-America-Asia-Europe loop. These services could technically represent capacity between Europe and America, but the sheer length of the routes involved means that cargo shipped that way will take months to arrive. Ultimately, I choose not to count these services as transatlantic, as it is highly unlikely that many shippers utilize these longer routes when there are faster services available on the Atlantic. These difficulties are one of the principal motivations behind reporting results based on both trade-level data (which are impacted by these choices) and route-level data (which are not).

The most significant issue in this data gathering process was the formal definition of an “alliance.” If one defines an alliance as a service on which some number of shipping firms co-operate to any degree, then there are literally hundreds of alliances. Indeed, beyond a few services operated by the largest shipping firms like MSC there are relatively few current services with only one operator. However, many of these smaller collaborations are not really shipping alliances in the sense that the word is commonly used. Instead, they involve either slot-sharing or the linking of one or two vessels from different firms that were already servicing given routes to allow firms to provide faster or more geographically varied services.¹⁰ Often they involve coordinating only a single service without any sort of global co-operation: for example, MSC and CMA-CGM might co-ordinate one set of sailings that link ports in Europe and Asia while not coordinating any other services linking Europe to Asia, let alone any sort of global or multi-trade cooperation.

The empirical work in this thesis is concerned with collaborations that require

10. Slot-sharing is when one shipping firm purchases space (“slots”) on another shipping firm’s vessel(s). It is a cost-effective way to maintain a low level of capacity on a route without having to commission a new vessel. When purchasing slots on another shipping firm’s vessel, the purchasing carrier is in effect acting like a customer, reserving a certain amount of space for a fixed period of time. While slot-sharing is often the mechanism by which alliances mix their cargo, slot-sharing by itself is the weakest form of co-operation in liner shipping as in many cases the slots are sold competitively between actual shippers and other shipping firms and involve no co-ordination beyond allowing the other shipping firm to own some space on another firm’s vessel.

substantial co-ordination and commitment by the shipping firms and can potentially provide substantial economic benefit (or wield substantial market power) due to their size. The low level of co-ordination in the smaller collaborations imply that there is no real commitment; indeed, anecdotal evidence from shipping industry publications suggests that alterations or terminations of these smaller collaborations are extremely common and in many cases are considered barely noteworthy. Conversely, a small collaboration operating on only a single route is unlikely to result in any serious market power since at that scale any collaborative venture has very little bargaining leverage. In many cases shippers could easily avoid dealing with the smaller collaborative venture by taking their business elsewhere. Even if this collaborative venture is the only group operating on that route, in many cases shippers could avoid shipping with them by utilizing a more round-about shipping route (shipping their output through a hub rather than directly).

With these data there is a strict trade-off between breadth of coverage and relevance of the results. Treating every collaborative venture as an alliance risks diluting the results by treating small and large groups as equivalent. For example, Das (2011) studies what factors influence alliance formation versus outright acquisition. In doing so he creates a database of all acquisitions and partnership events in the liner shipping industry from 1994-2006, allowing him to examine which factors influence acquisition probability. This approach requires treating collaborative arrangements as equivalent; Das' results thus may not hold for larger firms, who may be systematically different from the larger universe of all shipping firms and operators.

To avoid this issue, I utilize a strict definition of an "alliance." I define an alliance as a coalition of firms who co-ordinate activities on more than one trade. By this definition there are four alliances which are currently active: 2M, G6, CKYHE, and Ocean Three.¹¹ These four alliances are the only collaborative ventures large enough to involve multi-trade co-operation; indeed, they are the only collaborative ventures

11. CKYHE's name is inconsistently given as either CKYHE, the "Green Alliance," or CKYH-Evergreen. This work uses the shortest version.

which actually have names. To the extent that an alliance might offer an opportunity for market power abuse only these four alliances are likely large enough to wield that market power.

Perhaps more importantly, this definition brings this work in line with the larger literature (especially regulatory or industry publications) on this issue, which also restricts use of the term “alliances” to the four larger multi-trade collaborations. The commonly expressed worry is about the potential for market manipulation posed by collaborations between the largest firms (Bowman 2013; Dupin 2015). The definition of alliances adopted here keeps this empirical work focused on the major subject of ongoing regulatory debates regarding liner shipping. To measure which services are part of one of these four alliances, I used Alphaliner’s designations of services formally organized inside each major alliance. Thus, for the sake of feasibility, this work explicitly ignores the possibility that a non-alliance service operated by a member of that alliance might be relevant.

This process generates a data set of the average weekly capacity each major alliance was operating in each major trading area and between every bilateral nation-pair in February 2015 (the month in which the data were gathered). In the following section I explain how Alphaliner’s data was used to derive the same data over a longer time frame.

5.4.2 Historical Alliance Capacity Data

The most significant limitation in Alphaliner’s service database is that it has no temporal component; the numbers for each service summarize only the current configuration of that service. Thus the data above are, without further work, a cross section and in trade empirical work cross sections are naturally suspect, given the high likelihood that temporal factors may be driving observed differences in trading volumes. However, it is possible to use this list of services to derive similar information over a longer time frame.

Alphaliner - Service data									
CKYE / Evergreen - Trans Atlantic Express (TASCO / TAE / TAS-1 / NTA)									
Participants	K Line / Yang Ming / COSCO / Evergreen / slots : eastbound : FESCO								
Coverage	N. Eur / USEC								
Type	FC								
Sailing frequency	7								
Duration of rotation	28								
Ships used	4 x 4 200 / 5 000 teu then 4 x 5 500 / 6 000 teu								
Weekly capacity (teu)	4514								
Port rotation									
Antwerp, Bremerhaven, Rotterdam, Le Havre, New York, Norfolk, Charleston, Antwerp									
=> Note 1 - Norfolk : Evergreen ships are handled at 'APMT Terminal' while CKYH ships are handled at 'Columbus Terminal'									
=> Note 2 - Charleston : Evergreen ships are handled at 'North Charleston Terminal' while CKYH ships are handled at 'Norfolk International Terminal'									
FESCO slots limited to : New York, Norfolk, Charleston, Rotterdam, related only to US-Baltic trade via FESCO-ESF feeder services. FESCO slots on the trunk line but not for the North Sea ports.									
Comments									
Service organized in September 2009 by CKYH and Evergreen through the merger of the CKYH TAS 1 service (1071) and the transatlantic string of the Evergreen's NUE pendulum (M025) (See news). Zim takes slots from COSCO within a slot exchange agreement involving also the Zim's Med-US leg of the ZCS (M160) becoming later the ZCA (1665).									
> March 2012 - Capacity upgrade with the 2,800-3,000 teu ships replaced by 4,000-5,000 teu ones : SANTA PAOLA (5,042 teu), COSCO NAGOYA (4,506 teu), HANJIN PHOENIX (4,367 teu) and YM VANCOUVER (4,253 teu) (See news).									
> Jul 2013 - Zim ceases to take slots (See news).									
> Nov 2013 - FESCO takes slots on the eastbound leg for transshipment to/from Russia (See news).									
> May 2014 - Hanjin leaves (final voyage from Antwerp on 28 April) (See news). K Line to replace the Hanjin ship with VANCOUVER BRIDGE (See news).									
> May 2015 - Service upsized from 4,500 teu scale to 5,500-6,000 teu ones : YM MODERATION (Yang Ming) and EVER UNITED (Evergreen), GLEN CANYON BRIDGE (K Line), E.R. INDIA (COSCO).									
© Alphaliner									
Ships deployed									
Vessel Name	Typ	Flag	DWT	TEU	TEU 14	Speed	Gear	Operator	Open date
RHL FIDUCIA	cc	LBR	63,069	5,086	3,350	25.2	No	K Line	
COSCO NAGOYA	cc	PAN	50,686	4,506	2,800	24.5	No	COSCO Container Lines	
YM VANCOUVER	cc	CYP	50,632	4,253	2,805	24.5	No	Yang Ming	
EVER DEVOTE	cc	SGP	55,604	4,211		23.5	No	Evergreen Line (EMC)	(own)
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Figure 5.2: Service Details for TAE

There are two ways that Alphaliner's data can be used to create a time series of data on liner shipping capacity. For services that are still active, Alphaliner's data can be used to gather that historical information with great accuracy. While Alphaliner does not directly track historical capacity, for each service there is a "comments" section in which the analyst who compiled the information tracks how the particulars for that service have evolved over time, keeping track of changes in port distribution, ship sizes, and the firms involved. It is possible to examine how capacity has evolved over time for each service by examining these comments.

For example, Figure 5.2 shows Alphaliner's summary of the "TAS-1" service organized by the CKYHE shipping alliance, which is a transatlantic route linking

northern Europe to the U.S. east coast. The data at the top show that, as on February, it involved four ships linking the Netherlands, Germany, Belgium, and France to the U.S. with an average weekly capacity of 4,514 TEUs. However, the comments section shows that the service was initiated in 2009 as a co-operation between the then-separate CKYH alliance and the Evergreen shipping firm. The service initially launched with four ships in the 2800-3000 TEU range. In March 2012 the service upgraded to its current larger vessels, increasing its average TEUs. Finally, in May they intend to upgrade to yet-larger vessels. These comments thus demonstrate how this specific service contributed to CKYHE's market share on the transatlantic trade since September 2009.

If all services were still currently active in some modified form, then examining the comments for each active service would fully capture the evolution of shipping capacity. However, over time some services are abandoned or, more commonly, merged into new services to increase the efficiency of the shipping system. These "obsolete" services are the missing parts of Alphaliner's data and failing to account for them would understate market share for some firms or alliances, especially those which have undergone a major change in the distribution of their services. For example, most of Evergreen's services became obsolete when they joined CKYHE, as these services were folded into pre-existing CKYH services. There are almost no currently active Evergreen services which began prior to 2012. A complete history of liner shipping capacity must find some way to account for these missing services.

Alphaliner's database contains information on the "final" configuration of now-obsolete services, noting the port rotation, number of ships, historical evolution, and ship size *range* of all of these services at the time of their cancellation. What is missing from these data is a list of the ships involved and an estimate of weekly capacity, as Alphaliner does not retain that information after declaring a route obsolete. Thus, while these obsolete services can be used to derive data, to do so it is necessary to derive a capacity number from a number of ships and size range.

To do this, I assumed that the capacity of a service was, on average, equal to the


 Alphaliner - Service data	
///OBSOLETE/// - CKYH - North Atlantic service (TASCO 1 / TAS 1 / NTA)	
Participants	K Line / Yang Ming / COSCO / Hanjin / slots : Zim / CSCL
Coverage	N. Eur / USEC
Type	FC
Sailing frequency	7
Duration of rotation	28
Ships used	4 x 2 800 / 3 300 teu
Weekly capacity (teu)	
Port rotation	
Antwerp, Bremerhaven, Rotterdam, Le Havre, New York, Norfolk, Charleston, Antwerp	
Comments	<p>Service launched in January 2003 to replace both the TA strings of the AWP and AUE FE-USEC-Europe pendulums (M130 / M158) (thus reverting to the TAS 1 rotation -1070- as it was when combined with the FE-USEC 'AEX' service -2662- in June 2002, with however small differences in the USEC rotation). However, every of the four carriers involved used to participate to one of the two pendulums only, so that there is no change as they will continue to offer sailings once a week. The great change concerned the overall capacity which is considerably reduced. The move is a further step in the integration of the services of these four carriers in the wake of the agreement they concluded in September 2001 (See news). Ships assigned to the 1071 (phased in Jan-Feb 2003) : ZHONG HE, ELBE BRIDGE, MARE LYCIUM and HANJIN OSAKA. Zim followed as slot buyer on previous service M158 (See news).</p> <ul style="list-style-type: none"> > Due to the large ships shortage, from early 2004, the 4,000 teu ships (average capa : 3,960 teu) have been progressively replaced by smaller ships. 4,000 teu ships were sent on CKYH FE-USEC services. > September 2004 - Fully run with the new set of smaller ships (2,878-3,330 teu - average : 3,050 teu) (See news). > August 2006 - Zim has launched another TA service jointly with Italia Marittima : NEC (1117) (See news). > Nov 2008 - Capacity to be reduced by around 10% (from 3,060 teu to 2,725 teu) (See news). > Sep 2009 - CSCL ceases to buy slots (See news). Service merged with the transatlantic string of the Evergreen's NUE pendulum (M025) into one service (TAE - 1072) (See news). <p>© Alphaliner</p>
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<i>© Alphaliner 1999-2015</i>	

Figure 5.3: Service Details for TAS-1

midpoint of that service’s ship size range, unless the comments for that service suggest otherwise.¹² For example, Figure 5.3 shows Alphaliner’s data for the “TAS-1” service, an obsolete CKYH service which was folded into the TAE service shown in Figure 5.2. This example shows that this service operated from January 2003 to September 2009 with an initial capacity of 3960 TEUs, which was steadily reduced to 2725 TEUs throughout the decade before it was rendered obsolete. Despite the lack of data on ships and capacity, it is entirely possible to track how this service’s capacity evolved

12. In some cases even more detailed information is available. Occasionally, Alphaliner provides the actual names of the ships an obsolete service used, in which case it is possible to measure capacity directly by utilizing Alphaliner’s ship database. Wherever possible the data are based on that more accurate measurement.

over time.

Alphaliner's coverage of obsolete services is limited; Alphaliner only preserves information on services which are the predecessors of some active service, which is a common occurrence in liner shipping as many old services lead directly into similar new services. Thus data on TAS-1 are available because the service was a direct predecessor of TAE, a currently active service. The fact that obsolete services are frequently folded into current active services means that reconstructing capacity data for recent years is relatively reliable, as data on the obsolete services are widely available. However, the further back in time one stretches the more fragmentary data becomes and the more likely it is that services who have no current descendants are being missed, leading to potentially dramatic measurement errors.

To minimize the risk of these errors, the empirical work focuses on a relatively recent period in which data are reliable. Specifically, the empirical work uses data from January 2011 to February 2015. For the purposes of evaluating the impact of shipping alliances, this period covers the formation of all four of the current major shipping alliances, with G6 formed in 2011, CKYHE formed in 2012, and 2M and Ocean Three both formed in late 2014. If alliances truly pose market concentration concerns, then the effects of this market power should appear most dramatically in this fifty-month period as it is the time period in which current alliance system emerged.

More importantly, the chance of serious measurement errors in this period is relatively small. For the two major alliances that operated for the bulk of the period, G6 and CKYHE, data are quite easy to trace. For G6, 62% (18/29) of their currently active services were either active the entire sample period or are direct successors of pre-existing services for which there is data. This leaves 38% (11/29) of their services with no historical precedent; however, I can confidently state that these services are legitimately new rather than cases of missing data. G6 expanded its capacity linking the U.S. East Coast to Asia in 2013 and the U.S. west coast to Asia in 2014, and each of the eleven services for which there are no historical data are new services created in this capacity expansion (Alphaliner [2013a](#), [2013b](#)). Data on CKYHE are similarly

reliable. There are either current or historical data on 84% (27/32) of their currently active services for the full length of the sample period. Only 16% (5/32) of their currently active services are not directly traceable back to 2011, and these five services are legitimately new. For the final two major alliances, 2M and Ocean Three, each of their currently active services existed at their founding, which is to be expected as each of these alliances have existed for only about five months.

I used this historical data on currently active and obsolete services to expand the data set to measure the capacity decisions made by each of the four major alliances in every month between January 2011 and February 2015.

5.4.3 Alliance Market Share Data

The alliance capacity data can be used to derive market share data in each month of the sample for each of the three major “East-West” trading regions. Determining the market share controlled by a specific alliance requires data on the total weekly capacity of all liner shipping firms and alliances which operated on each of these trades. Alphaliner directly tracks these data. However, due to issues with Alphaliner’s database I was only able to retrieve these data for one year in the sample (2012) and up-to-date numbers for February 2015. To create a time series of overall capacity numbers there was no choice but to extrapolate from these more limited data. For the time period before 2012 I assumed that the per-month growth rate in overall worldwide capacity was a reasonable approximation of individual growth rates and extrapolated linearly using that number for each trading region. For 2012 on I extrapolated directly from each trade’s overall capacity number in 2012 to the overall capacity number in February 2015.

Combining these total capacity numbers with the data on alliance capacity by major trade generated monthly alliance market share data for each major trade. The extrapolated data are subject to measurement error.¹³ For example, there is a brief

13. This error arises from attempting to combine linearly extrapolated overall capacity data with

Table 5.1: Alliance Market Share Data by Year

Year	Mean	Std.
2011	20.3%	16.8%
2012	25.4%	20.1%
2013	29.6%	21.6%
2014	33.6%	25.28%
2015	51.8%	40.05%
Total	26.48%	21.13%

All figures are in percent of trade-level shipping capacity controlled by alliances.

period at the end of the sample during which these data imply that the share of capacity controlled by alliances in the Asia-North America trade is 100.3%, which is obviously incorrect. While the data may not precisely measure capacity shares there is no reason to believe that they systematically influence empirical results. Linear extrapolation might weaken the strength of the empirical tests but should not bias results.

Table 5.1 presents summary statistics for the market share controlled by all four alliances as a group on a trade level.

5.5 Trade Data

5.5.1 Trade Volume Data

To estimate equation 5.3 it was necessary to gather data on the dollar value of monthly bilateral trade or Y_{ijt} . I gathered these data for each exporter-importer pair in every month for which data exist, although for some exporter-importer-month combinations data are not available.

These data were gathered from the UN’s “Comtrade” database, which aggregates trade statistics from national governments and regional institutions such as Eurostat. Wherever possible these data are based on reported imports so that data on bilateral trade from nation i to nation j are generally measured as the imports reported

directly measured alliance capacity data. There are also some technical issues due to the way Alphaliner calculates its overall capacity numbers; for example, Alphaliner attempts to weigh multi-trade services (pendulums) at only part of their capacity value while I count them directly.

by nation j rather than the exports reported by nation i .¹⁴ Exceptions to this rule occur only when a nation fails to report data, in which case the bilateral trade data are based on reported exports.

A number of nations in the sample either do not report monthly bilateral trade data or only report those data with a significant delay. Twelve nations in the sample -Morocco, Bangladesh, China, Vietnam, the Bahamas, Jamaica, Taiwan, Oman, Saudi Arabia, the UAE, Peru, and Sri Lanka- do not report monthly data in the sample period. Other nations began reporting monthly data later than 2011; for example, both South Korea and Indonesia only began reporting these data in 2013.

This does not mean that monthly bilateral trade data are completely missing for these “non-reporting” countries because bilateral trade data is matched across nations. For example, the U.S.’s imports to and exports from Taiwan are, respectively, Taiwan’s exports to and imports from the U.S. For the non-reporting nations it is possible to measure trade with any reporting nation using export data. However, there are no data on trade between non-reporting nations; for example, there are no data on China’s exports to Taiwan or vice versa. For some nation-pairs bilateral data are missing even when both nations report data for that year; some countries fail to report imports from another country in a specific month. Given the sheer scale of the data set, constructing all individually missing import data using exports was infeasible. In cases of a single failure to report, I accepted the loss of data and only measured missing data using export data for countries that did not report any data in a year.

The data gathering process was further complicated by the fact that nations report bilateral trade volumes on different time scales, greatly increasing the number of non-reporting nations in more recent periods. In April 2015 only eleven countries

14. In the Comtrade Database import data are generally reported using “Cost, Insurance, and Freight” (CIF) valuation, which means the values assigned to bilateral trade include expenditures on shipping costs and insurance, making them a more accurate representation of the total value of economic activity *devoted* to exporting. Export data are generally reported using a “Freight on Board” (FOB) valuation, which means the trade values are reported as the value of the goods as they were loaded for transport, excluding expenditures on shipping and insurance.

Table 5.2: Bilateral Trade Summary Statistics

Year	N	Mean	Std.	Max	Sum
2011	17484	4.14	13.98	394.17	72,330.15
2012	17178	4.34	14.70	420.57	74,556.91
2013	18353	4.27	14.70	437.35	78,443.79
2014	18201	4.21	15.09	471.47	76,592.52
2015	1822	4.47	16.08	398.04	8,142.21
Total	73038	4.25	14.67	471.47	310,065.6

All values are in hundreds of millions of USD

in the sample had reported monthly bilateral trade for February, and only twenty-five had reported monthly bilateral trade for the whole of 2014. Because the Ocean Three and 2M alliances began formally operating and market concentration increased dramatically at the start of 2015, what happened to trade flows in the first two months of 2015 is extremely important in the empirical work.

Therefore, I relied on an unbalanced sample, using export data from reporting nations as a proxy for imports from non-reporting nations wherever possible and accepting the loss of some exporter-importer-month points. Gathering data using this process yielded 73,038 total month-exporter-importer data points. If every nation in the sample reported in every month there would have been 85,800 data points. Despite the various reporting issues in international trade data, I am able to locate data for 85% of the original sample.

Table 5.2 provides summary statistics for these data.

5.5.2 Trade Heterogeneity Data

Comtrade provides monthly bilateral trade data in specific product categories, down to the 2-digit Harmonized Tariff System (HTS) level. In addition to data on the overall value of nation-pair bilateral trade I also gathered data on value of bilateral trade for a set of specific products which are likely to be transported exclusively by liner firms, which allowed robustness tests to ensure that the empirical results are not being biased by the possibility of non-liner transportation.

Disaggregated data are very important when examining transportation issues. Trying to examine how liner shipping (or any form of transportation) impacts bilateral trade by using the overall volume of trade between nations always faces the risk that observed changes in trade flows might be driven by changes in alternate transportation sectors. Without a way to distinguish between the transportation methods used to carry products it is impossible to be sure if the empirical results are specifically measuring the effects of liner shipping,

While the choice of the nation-pairs included in the empirical sample negates the possibility that trade is being transported by land, two other forms of transportation are likely to be active between these nation-pairs. However, both of these alternatives are very focused on transporting specific categories of goods. On the high-value end of the goods spectrum there is heavy competition from air transportation. While still a trivial part of international trade by weight, air cargo is a substantial part of international trade by value, as air carriers usually only transport high-value, low-weight products whose producers place a high value on transportation speed (Hummels 2007). On the low-value end of the good spectrum most trade in commodities is transported by bulk shipping.¹⁵ Bulk firms are radically different from liner firms, with a market structure that relies heavily on spot markets for voyages and that is generally considered to be an almost perfectly competitive market (Veenstra 1999).

The fact that these alternate forms of transportation heavily focus on specific types of goods implies that with product-level data it is possible to measure trade using products that would typically only be transported by liner shipping firms. Specifically, I will later refer to trade in “container dominated” goods, which means products which would be mostly or entirely transported using container ships. This list of products is composed of 20 two-digit HTC-code categories of goods which are economically significant enough to be representative of a nation’s trade but also differentiated and physically heavy enough that they could not plausibly be transported by either bulk

15. Bulk shipping firms use vessels which are designed to carry only a single type of good, effectively filling the entire hull with one type of commodity such as ore, lumber, or petroleum.

Table 5.3: Product-Level Bilateral Trade Summary Statistics

Year	N	Mean	Std.	Max	Sum
2011	209,700	9.43	96.95	10,545.20	1,977,441
2012	209,472	9.60	104.15	12,529.86	2,011,190
2013	222,693	9.811	108.77	12,199.62	2,184,886
2014	221,701	9.77	112.14	14,002.73	2,166,483
2015	20,396	10.49	119.20	10,506.07	213,998
Total	883,962	9.68	106.12	140,002.73	8,553,978

All trade values are in millions of USD

or air. This implies that in the absence of land transportation the only viable method for transporting these goods is containerized liner shipping. Presumably trade in these goods has little or no risk of reflecting the effects of non-liner shipping sectors. Empirical tests which replace overall bilateral trade with trade in these categories should produce qualitatively similar results, allowing trade in these goods to serve as a robustness check.

The list of HTC codes included in the “container-dominated goods” is as follows;

- **Agriculture:** 03 (Seafood products), 04 (Dairy products), 07 (Fruits), 08 (Vegetables), 16 (Prepared meats), 17 (Sugar & sugar products), 19 (Prepared cereal & starch products), 20 (Prepared fruit & vegetable products), and 23 (Animal fodder & waste)
- **Manufacturing:** 33 (Cosmetics), 39 (Plastics), 42 (Leather products), 46 (Wood products), 48 (Paper), 61 (Clothing), 64 (Shoes), 73 (Steel & items thereof), 85 (Electronics), 94 (Furniture), and 95 (Toys and games)

Table 5.3 presents summary statistics for these data.

5.6 GDP Data

To empirically measure output (y_{it} and y_{jt} in equation 5.3) I gathered data on monthly GDP for each nation in the sample. This data gathering process faced the issue that there is a frequency mismatch between the other data sources and standard GDP reporting frequencies. There are no nations which report monthly GDP data and only a handful of richer countries which report quarterly GDP; less than a third of the nations in the sample report GDP numbers on even a quarterly basis. It was

Table 5.4: GDP Summary Statistics for Importing Nations.

Year	N	Mean	Std.	Max	Sum
2011	17484	154.13	254.08	1293.16	2,694,833
2012	17178	163.58	269.63	1346.93	2,810,043
2013	18353	170.21	282.63	1397.34	3,123,850
2014	18201	178.32	300.23	1581.32	3,245,570
2015	1822	222.57	352.96	1581.32	405,521
Total	73038	168.13	270.89	1581.32	12,300,000

All numbers are in billions of real PPP adjusted USD.

Table 5.5: GDP Summary Statistics for Exporting Nations

Year	N	Mean	Std.	Max	Sum
2011	17484	154.77	253.91	1293.16	2,705,946
2012	17178	163.05	269.66	1346.93	2,800,852
2013	18353	170.19	282.08	1397.34	3,123,449
2014	18201	178.64	299.77	1468.11	3,251,339
2015	1822	223.09	352.78	1581.32	406,483
Total	73038	168.24	279.59	1581.32	12,300,000

All numbers are in billions of real PPP adjusted USD.

thus necessary to extrapolate monthly GDP data from GDP data reported on longer time frames. Rather than combining data extrapolated from yearly GDP with data extrapolated from quarterly GDP I use the same yearly source for all nations to ensure consistency.

To create these data, I gathered yearly GDP data for each nation in the sample from the IMF's "World Economic Outlook" Database. Due to lags in reporting, especially for poorer nations, some of these reported yearly figures are IMF estimates. I then assumed that a nation's monthly GDP equaled its yearly GDP divided by twelve. Table 5.4 shows these data for the set of importing nations, while table 5.5 shows these data for the set of exporting nations.

Due to the potential for reporting errors there is no reason to believe that the data in table 5.4 would precisely match the data in table 5.5. For example, if Singapore failed to report its imports from the United States in one month then the U.S. would be missing from the set of exporters for Singapore that month, creating a gap between

the overall importer and exporter sets. However, while these importer and exporter GDP data are not precisely identical they are extremely similar; average importer GDP is 99.93% of average exporter GDP. The fact that these gaps are small suggests that reporting errors are unlikely to significantly impact the empirical results.

5.7 Distance Data

The final data source necessary to estimate equation 5.3 was a measure of the distance between nations. For each nation-pair in the sample I gathered data on the “population-weighted” distance between them, a measure of distance which estimates the distance between nations as a population-weighted function of the distances between each nation’s major cities.

In the trade literature measures of distance are meant to capture how far goods need to travel to move from one nation to another and thus, presumably, how expensive it is for two nations to trade with each other. Traditionally, empirical trade research has relied on what can be called “point-to-point” distances, which measure the distance between two nations as the distance between two representative physical points in each nation (Head and Mayer 2002). A common application of these methods has been to measure the “Great Circle” distance between the two nation’s capitals.¹⁶

However, recent research indicates that measuring distance with point-to-point measures is problematic because such measures do not accurately reflect the distance between either nations’ economic centers. Therefore, I utilize the weighted distance measure first introduced by Keith Head & Thierry Mayer and available through CEPII (Mayer and Zignago 2011). This statistic measures the distance between two nations as a function of the bilateral distances between the major cities in each nation weighted by those cities’ share of national population. Formally, it measures the distance between

16. A Great Circle distance is a simple application of trigonometry to derive the shortest distance between two points on a surface of a sphere given each position’s latitude and longitude.

Table 5.6: Distance Summary Statistics

N	Mean	Std.	Max	Sum
73,083	8975.79	4455.48	19649.83	65,600,000

All numbers are in “population weighted” kilometers.

any two nations i and j with the following theoretically derived equation:

$$d_{ij} = \left(\sum_{k \in i} (\text{pop}_k / \text{pop}_i) \sum_{\ell \in j} (\text{pop}_\ell / \text{pop}_j) d_{k\ell}^\theta \right)^{1/\theta} \quad (5.5)$$

where k and ℓ are indexes of the “major” cities in each nation, “pop” represents the population share in each respective city or nation, d represents the bilateral distance between each city pair, and θ is an index of how responsive trade is to distance, estimated to be approximately -1 in the gravity model literature.

By taking account of the distance between every major production center, this statistic more accurately captures the economic concept of distance, which depends as much on the distribution of output as it does on physical distances.¹⁷ Furthermore, this statistic has held up well in empirical testing and has resolved several trade “mysteries” that were the result of inaccurate distance measures (Head and Mayer 2002).

Table 5.6 presents summary statistics for this “population-weighted” distance measure in the nation-pair sample.

17. For example, in an economic sense it is entirely possible for two nations to grow further or closer apart if the distribution of economic activity in one nation moved, even though obviously physical distances are invariant to time.

Chapter 6

EMPIRICAL COMPARISON OF THE FOUR MAJOR ALLIANCES

To motivate the empirical results this chapter presents information and summary statistics for the four major liner shipping alliances, based on the capacity data set defined in Chapter 5. This type of direct comparison is the primary form of empirical analysis in the extant literature (see, for example, Panayides and Wiedmer (2011)). However, as this analysis of each alliance's characteristics demonstrates, there is a shocking degree of similarity between the major alliances; there is no easy way to categorize some alliances as potentially harmful based on either their composition or their commercial behavior. Formal empirical testing is necessary to examine the economic impacts of shipping alliances; these empirical results are presented in Chapter 7.

6.1 Basic Information on the Four Major Alliances

This section examines each alliance's general characteristics (size, national distribution, etc.), while the following sections examine their commercial behavior. There are some differences between the major alliances in these characteristics, but it is difficult to determine if those differences are of any substantial economic consequence in the absence of more rigorous empirical testing.

Based on Alphaliner's data on overall capacity amongst the top-twenty largest shipping firms in January 2015, O3 and CKYHE are relatively small alliances, with combined member capacities of 14.8% and 17.1%, respectively, of total world shipping capacity. G6 and 2M are the larger alliances with, respectively, 18.4% and 29.1% of world capacity. However, there is no consistent trend in individual firm sizes beyond the fact that 2M is composed of the two largest firms in the world; the other three

major alliances' memberships are widely dispersed in terms of firm size.¹ While it is fair to say that 2M is the largest alliance in the world by a substantial margin, there is little to distinguish the other three shipping alliances in terms of overall capacity

There are some differences in the regional origin of each alliance's member firms, although given the global nature of the industry it is unclear to what extent a firm's national origin would be relevant for business decisions. 2M and G6's members tend to be from comparatively richer nations; 2M's members are Dutch and Swiss, while G6's members are from Korea, Germany, Hong Kong, Singapore, and two from Japan. O3 and CKYHE tend to include a higher proportion of firms from less developed nations; O3's membership is French, Chinese, and Arabic, while CKYHE's members are from Korea, China, Japan, and two from Taiwan.² The only European firm in the latter group is CMA-CGM, a French firm whose entry into O3 was a hasty response to the rejection of the P3 alliance (an event covered in more detail in Chapter 8), which would have only included European members. Two alliances, 2M and CKYHE, are explicitly regional, involving only firms from a specific continent and there are signs that shipping firms prefer to form alliances with shipping firms that, at the least, are from similarly developed nations.

It might seem intuitively appealing to examine the internal structure of the major four alliances; perhaps some alliances are more tightly organized while others are looser. However, at least in terms of publicly available information, there are no obvious differences in the organizational structure for any of the alliances. This can be shown by examining the documents each alliance has to file with the U.S. Federal Maritime Commission (FMC) to gain operational approval, specifically FMC Agreements No. 012293, 012300, 012194-002, and 012299 for, respectively, the 2M,

1. Numerically, in global capacity rankings G6's members are 4th, 10th, 11th, 12th, 14th, and 18th. O3's are 3rd, 7th, and 15th. CKYHE's are 5th, 6th, 8th, 13th, and 16th.

2. Technically, UASC in the O3 alliance is from the United Arab Emirates, but it was founded as a joint venture between various Arab nations along the Persian Gulf rather than just the UAE and "Middle Eastern" or "Arabic" are more accurate descriptions of its origin.

CKYHE, G6, and O3 alliances. These agreements specify the mechanism each alliance uses to establish “widespread” changes (such as significant changes to capacity levels or route selections) or to amend or dissolve their existing agreement. For all four alliances this mechanism is either a vote by an executive committee (composed of the member firms) or an unspecified process of reaching agreement amongst of its members. This “executive committee” structure is so widespread that some financial analysts have criticized it as being too inflexible to allow alliances to utilize more complete forms of co-operation (such as co-operating in negotiations with port owners) to achieve higher profits (Tirschwell 2014). While it is entirely possible that the bargaining system within each alliance may be radically different, there is no publicly available way to determine if this is the case, as such internal arguments would be proprietary information.

While there are some differences amongst the alliances in their general characteristics, it is hard to draw anything more than suggestive conclusions based on these differences. Certainly, the visibly obvious differences are not consistent enough to justify serious regulatory decisions; given the lack of any obvious way to distinguish alliances based on these characteristics, regulatory decisions should instead be based on information about each alliance’s commercial decisions or economic impact.

6.2 Current Alliance Service Distribution

This section examines the geographic distribution of each alliance’s current service structure. Table 6.1 summarizes the activities of the four major alliances along the three major trades as of February 2015, showing the number of services, the total number of ships operating by all services, and both the total and mean weekly capacity in TEUs for all services.³

3. The month one gathers these data can impact the results, as a small number of services do not operate in the winter due to depressed trade volumes. For example, in the winter G6 merges two larger services, named “NYE” and “SCE,” into one smaller winter service called “NYE-Winter” to save on capacity costs. While these seasonal services are rare, their existence implies that the numbers in this table will fluctuate slightly over the course of the year even if no changes are made to the overall service structure.

Table 6.1: Current Alliance Behavior

Trade	Statistic	2M	Ocean Three	CKYHE	G6
Transpacific	Number of Services	5	5	19	17
	Number of Ships	76	47	161	145
	Total Weekly Capacity	44,563	43,469	122,837	121,001
	Mean Weekly Capacity	8,913	8,694	6,465	7,117
Transatlantic	Number of Services	5	0	4	4
	Number of Ships	29	0	48	32
	Total Weekly Capacity	31,402	0	26,534	21,732
	Mean Weekly Capacity	6,280	0	6,634	5,433
Asia-Europe	Number of Services	11	8	9	8
	Number of Ships	135	87	105	87
	Total Weekly Capacity	138,901	82,783	90,253	83,978
	Mean Weekly Capacity	12,627	10,473	10,028	10,497

As of February 2015, based on data from Alphasiner.

Table 6.1 shows that there is a surprising degree of homogeneity in alliance behavior, especially between the two younger alliances (2M and O3) and the two older alliances (G6 and CKYHE). CKYHE and G6 exhibit extremely similar levels of overall capacity and very similar geographic distributions, although they differ substantially in the number of ships used and the number of ports visited. CKYHE uses more ships, which implies that their average vessels are smaller, which allows them to reach more ports. G6 services are more focused, visiting a smaller number of ports with larger vessels.

The two newer alliances, 2M and O3, are also quite similar in their structure on the Transpacific and Europe-Asia trades, with the important caveat that 2M is considerably larger than O3. Both of these new alliances focus the majority of their activity on the Europe-Asia trade, with smaller commitments to the Transpacific trade. They differ substantially on the Transatlantic trade, where 2M dominates the trade and O3 does not operate any services. Both newer alliances utilize larger individual vessels than the older alliances, with 2M's average Europe-Asia vessel size exceeding 10,000 TEUs of capacity.

Table 6.2: Per-Service Capacity Evolution over Time

	CKYHE			G6		
	Asia-NA	Europe - NA	Europe - Asia	Asia-NA	Europe - NA	Europe - Asia
2011	5,646	4,273	7,252	5,468	4,055	6,921
2012	5,574	4,844	8,433	5,597	4,249	7,911
2013	5,553	4,974	8,910	5,954	4,288	9,278
2014	6,138	5,930	9,549	6,501	4,966	10,393

Each figure is based on the average monthly values in that year. Based on data from Alphaliner.

Despite some interesting cross-sectional differences in the major alliance's geographic behaviors there is nothing in these tables that provides any indication about which alliance(s) may be either beneficial or detrimental to trade. The major alliances are simply too similar in their behavior to differentiate them in this way.

6.3 Historical Alliance Service Distribution

Table 6.1 summarizes the current distribution of alliance services. 2M and O3 have only existed for a short period of time and have not yet experienced any substantial variation in their service structure. G6 and CKYHE, however, are older and their service structures have undergone substantial changes over time. This section presents information on how those alliances' services have evolved during the sample period. Table 6.2 shows each alliance's average per-service weekly capacity by major trade from 2011-2014, while table 6.3 shows each alliance's average total weekly capacity by major trade for the same years.

Tables 6.2 and 6.3 both demonstrate a convergence in alliance behavior as both alliances shifted towards a global focus in the last five years. Initially, CKYHE and G6 are oriented towards specific trades, with CKYHE heavily focused on the Transpacific trade and barely operating on other trades, while G6 was similarly focused on the Europe-Asia trade and much less involved in the other trades. This does not necessarily imply that the firms in either alliance were not active in the other regions, only that their co-operation was highly trade specific; they likely operated independently

Table 6.3: Total Capacity Evolution over Time

	CKYHE			G6		
	Asia-NA	Europe - NA	Europe - Asia	Asia-NA	Europe - NA	Europe - Asia
2011	84,225	12,819	14,503	37,005	24,328	68,609
2012	95,608	18,262	66,894	39,180	25,495	69,280
2013	99,936	19,987	89,844	52,805	25,728	75,671
2014	112,987	24,216	90,253	115,706	28,280	83,145

Each figure is based on the average monthly values in that year. Based on data from Alphaliner.

or in smaller collaborative groups on the other trades. As late as 2011-2012 many alliances were still largely regional, focused on specific areas with only minor operations elsewhere.

Over time these distinctions began to dissolve as each alliance oriented itself towards a world in which alliances were competing with other globally-oriented alliances rather than co-operating in specific regions. This growth was driven by a combination of shipbuilding and, more significantly, bringing pre-existing ships and services into the alliance structure. Several of the larger increases in total capacity are far too rapid to have been the result of pure ship-building and instead would have had to occur through firms committing more and more of their vessels to the alliance system; these data show increasingly large commitments to the alliance system.

The convergence in the distribution of capacity amongst these alliances emphasizes the increasingly global nature of the alliance system. Even at the height of the conference system co-operation in liner shipping was largely on a region-by-region basis; the “global” alliance system which has emerged in the last four years is fundamentally different from the previous organization of the liner shipping industry. To emphasize the globalization of the alliance system, table 6.4 shows the average number of services operated by each alliance in each trade from 2011-2014 and table 6.5 shows the number of vessels each alliance operated in each trade during the same period.

Tables 6.4 and 6.5 show the same pattern as the capacity data; very significant differences in alliance structure and behavior in 2011 are steadily erased and by 2014

Table 6.4: Number of Services over Time

	CKYHE			G6		
	Asia-NA	Europe - NA	Europe - Asia	Asia-NA	Europe - NA	Europe - Asia
2011	15	3	2	7	6	10
2012	17	4	8	7	6	9
2013	18	4	10	9	6	8
2014	18	4	9	18	6	8

Each figure is based on the average monthly values in that year. Based on data from Alphaliner.

Table 6.5: Committed Ships over Time

	CKYHE			G6		
	Asia-NA	Europe - NA	Europe - Asia	Asia-NA	Europe - NA	Europe - Asia
2011	107	27	24	63	55	99
2012	130	38	81	67	55	89
2013	143	42	109	90	56	87
2014	152	46	106	158	51	86

Each figure is based on the average monthly values in that year. Based on data from Alphaliner.

there are only small differences between the two alliances. The only significant remaining difference is that G6 utilizes and always has utilized larger overall ships, while for the most part CKYHE appears to have always relied on smaller vessels. These results and the results in section 6.2 do not show any significant differences in the commercial behavior of the major alliances. The gaps that did exist have steadily eroded over time, to the point where the major alliances are now broadly similar. Again, there is no obvious way to differentiate the major alliances, making it difficult to draw any conclusions about their potential economic effects.

6.4 Analysis of “Cross-Slotting” Behavior

While it is not possible to directly examine internal alliance negotiations, as these negotiations are proprietary, one way to examine the extent to which alliances are able to control their member firm’s behavior is to examine the frequency with which alliance members seem to deviate from that alliance’s service structure. This section examines the average frequency with which members of an alliance purchase slots on another alliance’s services. While these sorts of “cross-slot” agreements are

Table 6.6: Alliance Purchase Matrix

		Purchased From			
		2M	G6	CKYHE	O3
Purchased By	2M	–	1 (3.8%)	0 (0.0%)	0 (0%)
	G6	0 (0%)	–	3 (10.7%)	0 (0%)
	CKYHE	0 (0%)	2 (7.7%)	–	10 (76.9%)
	O3	0 (0%)	0 (0%)	15 (53.5%)	–

Based on data from Alphaliner. As of February 2015.

not uncommon and are not necessarily something a specific alliance would object to, a high frequency of them might reasonably be taken to suggest a low level of alliance control, whereas a low frequency suggests an alliance that is more internally focused.

Table 6.6 shows how frequently members of each alliance purchases space on other alliances' services. Each entry shows the number of services operated by the column alliance upon which at least one member of the row alliance has purchased slots, with the implied percent of the column alliance's services with slots purchased by the row alliance's members in parentheses. This table only include purchases of slots by members of the other major alliances, ignoring slot purchases by firms who are not a member of any major alliance. In the modern industry the small number of shipping firms who operate internationally but are not members of the major alliances are forced to rely on significant slot purchases to survive, as they do not have enough ships to offer a sufficiently diverse geographic coverage with their own vessels. Examining all slot sales risks diluting the value of the analysis by including firms who are more customers than rivals.

Table 6.6 demonstrates that there are clear distinctions between the slot purchasing behaviors of the major alliances; 2M and G6 are largely closed; they rarely sell slots to outside firms and their members rarely purchase slots on other alliance's services. In contrast, CKYHE and O3 are largely open; many or even most of their services sell space to members of rival alliances and their members frequently collaborate with non-member firms.

This is an important point, because if alliances are meant to achieve technical

efficiencies there is no *per se* reason to avoid selling slots to any possible takers. The goal of a purely efficiency seeking alliance is to ensure sufficient cargo to fill a larger vessel's hold, thereby utilizing economies of scale in ship size; whom that cargo belongs does not impact that goal. A lack of cross-slotting is thus at least suggestive evidence for an alliance having goals beyond simple technical gains, such as focusing trade into a specific routing system or enhancing their members' bargaining positions. At the least it implies an alliance with a strong control over its member firms' shipping volumes. While one could argue that this is a result of more careful alliance planning by the closed alliances, leaving member firms no reason to go outside of the alliance structure -there is an at least plausible explanation for this gap- the starkness of these results suggests that it instead represent a difference in alliance discipline.

In summary, there are surprisingly few differences between the major shipping alliances; in terms of legal, geographic, and even for the most part capacity structure the four major alliances are strikingly similar. The only notable differences between the four major alliances are in overall size and the frequency with which their members deviate from the alliance structure. Both of these facts are at most suggestive, though, and in general there is no obvious way to draw conclusions about the economic impacts of the different alliances based on these fairly scant differences. Formal empirical analysis is necessary to determine how these alliances are impacting trade; it is necessary to directly evaluate the economic *impact* of the major alliances, as there is no other obvious way to differentiate them.

Chapter 7

EMPIRICAL RESULTS ON THE ECONOMIC IMPACT OF SHIPPING ALLIANCES

This chapter presents the empirical results from using the specification defined in Chapter 5 to evaluate the impact which shipping alliances have had on the international trading system. These results examine how expansions of the alliance system over the last four years have impacted trade volumes.

The theoretical results presented in Chapters 3 and 4 imply that alliances can be either trade enhancing or trade inhibiting depending on how shipping firms behave in the absence of alliance formation. The empirical results in this chapter directly examine whether alliances inhibit or encourage trade, estimating whether alliance-dominated trades and routes have higher or lower trade flows. As established in Chapter 5, the key decision variable for each alliance is the amount of capacity they deploy in each area; thus, an alliance-dominated area is one in which shipping alliances control most or all capacity. Using data on the capacity controlled by each alliance in each area, I examine how changes in alliance capacity between each nation-pair impacted their bilateral trade volume.

I find that there are some signs that alliances inhibit trade in a manner consistent with market power, suggesting that regulatory scrutiny of shipping alliance is entirely justified. Robustness checks which repeat the same empirical tests for product-level data and on subsets of data in which there is almost complete data coverage produce similar results. However, these effects are not consistent across geographical measures of alliance capacity, nor are they consistent across empirical specifications, suggesting that caution and humility are warranted before drawing hard conclusions about the value of shipping alliances. Empirical tests which examine each alliance separately

Table 7.1: Overall Shipping Alliance Effects

Trade			Route		
Variable	Coefficient	Std. Err.	Variable	Coefficient	Std. Err.
Intercept	-66.025**	5.807	Intercept	-66.673**	5.813
lnDistance	21.806**	2.448	lnDistance	22.077**	2.451
lnExportGDP	0.446**	0.101	lnExportGDP	0.443**	0.101
lnImportGDP	1.255**	0.101	lnImportGDP	1.253**	0.101
Capacity	0.008**	0.002	Capacity	0.008**	0.002
AllianceMarketShare	-0.032	0.046	AllianceMarketShare	-0.028	0.046
			IndividualCapacity	-0.012*	0.005
N		73038	N		73038
R ²		0.936	R ²		0.936
F _(1650,71387)		635.899	F _(1651,71386)		635.555

Significance levels : † : 10% * : 5% ** : 1%

show that the only major alliance with consistently negative effects on trading volume is CKYHE; there is no statistically significant relationship between trading flows and the other three major alliances' market activities. This implies that the overall negative effects may have been the result of aggregation issues. Given the fact that the vast majority of alliances do not appear to be inhibiting trade it seems prudent to avoid any potentially damaging regulatory actions against shipping alliances.

7.1 Alliance Effects on the International Trade System

7.1.1 Overall Trade Volume Effect of Shipping Alliances

This section presents the results for estimating the impact that shipping alliances have had on trade, combining all four major shipping alliances when measuring alliance market share and alliance controlled route capacity. Section 7.1.2 presents results which decompose these variables by the four major alliances. The “overall” results are presented in table 7.1.

The coefficients for the gravity model terms are quantitatively similar for both the trade- and route-level results: higher levels of GDP are correlated with higher levels of bilateral trade.¹ The results for the economic impact of the total capacity fielded

1. The coefficient on distance is extremely counter-intuitive and hard to believe, implying that increasing the distance between a nation pair leads to *higher* trade between those nations. This

by all shipping firms are quantitatively identical on both geographic scales; a higher overall capacity in a trading region is correlated with higher trade between nations in that region. Specifically, the addition of 10,000 TEUs of overall capacity in a trading area is expected to increase bilateral trade between nation-pairs in that area by .8%, an effect that is economically substantial given that the weekly overall TEUs in the major trades frequently expands by five to ten thousand per year (leading to equally frequent concerns about overcapacity in the liner shipping industry).

The trade-level results show no indication that alliances can utilize market power. Numerically, the trade-level results suggest that if the combined market share controlled by all shipping alliances in a nation-pair's trading region increases by 10% (holding capacity constant) then their bilateral trade is expected to fall by roughly .3%. Even interpreted literally this effect is small, implying that if alliances expanded from their current average trade-level market share of roughly 50% to 100%, bilateral trade in that region would only decrease by about 1.5%. More importantly, this effect is statistically insignificant; nothing in the trade-level results supports the claim that shipping alliances are able to utilize market power.

It is almost certain that operational agreements like alliances allow shipping firms to deploy larger vessels. Thus, expansions of the alliance system have almost certainly contributed to the increases in worldwide overall capacity over the last fifteen years. The trade-level results thus suggest that alliances have increased the volume of trade; given the positive relationship between overall capacity and bilateral trade, any result which suggests that expansions of alliance market share do not actively inhibit trade must be interpreted as a pro-alliance result. At the worst the trade-level results give no indication that alliances are exercising market power and the potential for

result can be explained the presence of exporter-importer pair effects, which rob the distance term of statistical power as the distance between two nations does not vary with time. Thus, it is unlikely that this term has any statistical power in a test with exporter-importer fixed effects. Results which use only nation fixed effects produce the standard negative effect from distance (i.e., this result does not stem from a fundamental data issue) and results which exclude distance entirely with exporter-importer pair effects produce quantitatively similar coefficients (i.e., this effect does not appear to be distorting the empirical results).

technical efficiencies from alliance formation suggests that alliances are a net positive for the trading system.

The route-level results are more complex; while trade-level alliance market share has no statistically significant effect on trade volumes, route-level capacity (the TEUs of capacity alliances operate between that nation-pair) has a statistically significant negative effect on trade volumes. Specifically, holding overall capacity and alliances total market share constant, an increase in route-level alliance controlled capacity of 10,000 TEUs is expected to cause a 1.2% decrease in bilateral trade volume. This represents the effect of alliances altering their vessel routing system (while leaving their overall trade-level capacities unchanged) to deploy more capacity between two specific nations, in effect focusing their operations more heavily on that specific nation-pair. Even if alliances expanded their route-level capacity by adding new ships (leading to an equally large increase in overall trade-level capacity) the expected effect on trade is still a .4% decrease in trade volume. This negative effect on trade volume is consistent with alliances exercising market power (inhibiting trade by abusing a dominant market position) and inconsistent with alliances attaining significant technical benefits without utilizing those benefits for market power purposes.

However, route-level results must be interpreted carefully given the fact that route-level data may not be an accurate representation of the actual capacity between nation pairs. This is particularly true in a hub-and-spoke system, in which the connection between route-level capacity and actual trade volume may not be strong. It may well be the case that alliance's "over-deploy" capacity between hubs, leading to capacity between nations hub-containing nations which is not consistent with the actual trade volume between those nations, thus implying a (spurious) negative relationship between route-level capacity and trade flows.

Still, at the very least there are signs that alliances are utilizing market power, suggesting that regulatory responses to alliance formation may be justified. However, the fact that there is no negative relationship between overall alliance market share and trade volume cautions against interpreting this result too broadly; it is difficult to

justify drawing strong conclusions about the economic impact of alliances unless both terms demonstrate the same relationship.

7.1.2 Testing for Differences Amongst the Alliances

The previous section’s empirical results were based on data measuring the impact of all four major alliances combined (that is, examining the impact of shipping alliances as a group rather than individually). This section presents results which examine the four major shipping alliances (2M, G6, CKYHE, and O3) separately. These results show that there are no signs that three out of the four major shipping alliances (2M, G6, and O3) are utilizing market power, with no statistically significant relationship between any of these alliances’ capacity and trading volumes. There are substantial signs that the final major alliance, CKYHE, is utilizing market power, as CKYHE capacity has a strongly negative effect on trading volumes.

These results repeat the empirical tests from section 7.1.1 with separate coefficients for each alliance. For the trade-level empirical specification alliance market share is replaced by variables which measure the capacity fielded by each of the four major alliances in that trade, scaled to the 10,000 TEU level. For example the variable “G6Capacity” is equal to the total capacity fielded by the G6 alliance on that nation-pair’s trade.² For the route-level empirical specification Individual Capacity is decomposed into the individual capacity fielded by each alliance: for example, “O3IndividualCapacity” is equal to the weekly TEUs linking each bilateral nation pair operated by the O3 alliance. Table 7.2 displays the results from these tests.

For three out of the four major shipping alliances there are no signs of significant differences in their economic impacts; there is no statistically significant relationship between 2M, G6, or O3 trade- or route-level capacity and bilateral trade flows. Given

2. These overall alliance capacity terms are expressed in TEUs rather than market share percentages to allow direct comparison of the coefficient for each alliance term with the coefficient for overall capacity. An alliance market share term would be measured as each alliance’s trade-level capacity as a percentage of overall trade-level capacity. Thus, the fact that the empirical test includes overall capacity implies that empirical tests based on market share terms would produce qualitatively identical results (as these variables would be composed of variables which are in the presented empirical results).

Table 7.2: Disaggregated Alliance Results

Trade			Route		
Variable	Coefficient	Std. Err.	Variable	Coefficient	Std. Err.
Intercept	-65.849**	5.816	Intercept	-66.878**	5.816
lnDistance	21.738**	2.455	lnDistance	22.168**	2.453
lnExportGDP	0.449**	0.102	lnExportGDP	0.440**	0.101
lnImportGDP	1.256**	0.102	lnImportGDP	1.251**	0.101
Capacity	0.008**	0.002	Capacity	0.008**	0.002
2MCapacity	-0.001	0.010	AllianceMarketShare	-0.026	0.046
CKYHECapacity	-0.006**	0.002	2MIndividualCapacity	-0.014	0.024
G6Capacity	0.002	0.002	CKYHEIndividualCapacity	-0.017 [†]	0.009
O3Capacity	-0.008	0.014	G6IndividualCapacity	-0.013	0.011
			O3IndividualCapacity	0.018	0.040
N		73038	N		73038
R ²		0.936	R ²		0.936
F _(1653,71384)		634.873	F _(1654,71383)		634.387
Significance levels : † : 10% * : 5% ** : 1%					

the possibility that alliances can utilize technical efficiencies which justify expansions of overall capacity, statistically insignificant relationships between market share and bilateral trade support the concept that these alliances are beneficial to trade. There is no sign that any of these three alliances are inhibiting trade and there are signs that they are actively encouraging trade through expansions of overall capacity.

On both a trade- and route-level the empirical results suggest that the CKYHE alliance is inhibiting trade volume. On a trade-level, a 10,000 increase in the TEUs of capacity operated by CKYHE is expected to cause a .6% decrease in bilateral trade volume. The net effect of the CKYHE alliance on trade volume might still be positive if they operated exclusively through expanding capacity (in which case each expansion is expected to lead to a .2% increase in bilateral trade). However, it is extremely unlikely that this is the case, as alliances generally draw capacity from a combination of new shipbuilding by their member firms and re-organizing the existing ships operated by their members in a pooled alliance service system.

On a route-level the negative relationship between CKYHE and trade volume is even stronger: a 10,000 TEU increase in CKYHE operated TEUs operating between two nation pairs is expected to decrease those nations' bilateral trade volume by 1.7%,

and even if this increase is accomplished exclusively with new capacity the net effect is still expected to be a roughly 1% decrease in bilateral trade volume. However, this effect is only statistically significant at the 10% level and thus must be interpreted with extreme caution. At the very least, however, the coefficient sign in both levels of regressions suggests that expansions of CKYHE lead to decreases in bilateral trade flows, even if the effect is statistically weak on a route-level.

Thus, for the most part the current alliance system appears to be a net positive to the global trading system; there are no indications that three of the four major shipping alliances (whose combined membership represented roughly 62.3% of global capacity in February 2015) are utilizing market power to a sufficient enough degree to inhibit trade flows. However, these results imply that the CKYHE alliance (whose membership controlled roughly 17.1% of global capacity in February 2015) is inhibiting trade. This result suggests that the CKYHE alliance is utilizing market power in a trade-inhibiting way, or, at the most generous, that their operations are sufficiently inefficient that they substantially inhibit trade volume. The second option is at least within the realm of possibility; CKYHE contains Cosco, a Chinese state owned enterprise which has been accused of making inefficient decisions due to political constraints (Bhattacharya 2014). At the very least, the seemingly trade inhibiting impact of CKYHE implies that regulatory groups should carefully examine the market behavior of the CKYHE alliance to ensure that it is not abusing its market position.

7.2 Alliance Impacts on Product-Level Trade Volume

7.2.1 Introduction

This section presents results testing the impact that alliance behavior has on trade in the “container dominated” subset of goods defined in section 5.5.2. These results are a robustness check to ensure that the empirical results are not being impacted by the availability of alternate forms of international transportation. These estimates repeat the empirical work in sections 7.1.1 and 7.1.2 using product-level trade data for Y_{ijt} instead of overall trade data, adding product fixed effects. For shipping alliances

as a group substituting product-level data produces qualitatively different results, with trade-level alliance capacity negatively correlated with trade volume and route-level alliance capacity having no statistically significant effect, although these results support the same general conclusion as the original empirical results. When examining each alliance separately empirical tests based on product-level data produce qualitatively similar results in the sense that there is no consistent evidence that alliances in general are utilizing market power, although the results are quantitatively very different.

There are two caveats when attempting to use monthly product-level trade data. First, product-level bilateral trade data are less available than overall bilateral trade data, especially at a monthly frequency. Many nations either do not report these data or only report them on a significant delay for a subset of other nations. Converting from data on bilateral trade to data on product-level trade expands the overall sample size from 73,038 to 887,046. Thus, the average importer-exporter-month combination in the original sample reports data for only 12 of the 20 product categories for each month, implying a substantial volume of missing data. Furthermore, some of these data may have significant measurement error in the form of incorrectly categorized goods, which is not a problem for overall bilateral trade data. While these data issues are unlikely to bias the empirical work, as there is no reason to believe the missing data are non-randomly distributed, they certainly imply that the results should be interpreted only loosely.

Second, while the results reported in this section continue to use [5.3](#) as the empirical specification to preserve comparability with the other empirical results, at a product-level there is no reason to believe the typical gravity model outcomes will occur. This is particularly true in regards to the impact of GDP on trade; while it is entirely plausible that larger economies naturally have larger overall trade volume there is no reason to believe this relationship is true for trade in all or even most specific product categories. At a product-level trade is primarily the result of comparative advantage; if a nation had no iron mines, for example, there is no reason to believe that an increase in that nation's economic size would naturally lead to an increase in

Table 7.3: Overall Shipping Alliance Impact on Product-Level Trade

Trade			Route		
Variable	Coefficient	Std. Err.	Variable	Coefficient	Std. Err.
Intercept	-113.369**	5.291	Intercept	-113.238**	5.294
lnDistance	39.919**	2.217	lnDistance	39.867**	2.218
lnExportGDP	0.037	0.090	lnExportGDP	0.037	0.090
lnImportGDP	0.652**	0.093	lnImportGDP	0.651**	0.093
Capacity	-0.001	0.002	Capacity	-0.001	0.002
AllianceMarketShare	-0.105**	0.039	AllianceMarketShare	-0.106**	0.039
			IndividualCapacity	0.003	0.004
N		887046	N		887046
R ²		0.489	R ²		0.489
F _(1664,885381)		508.777	F _(1665,885380)		508.471
Significance levels : † : 10% * : 5% ** : 1%					

its export of steel goods. There is no reason to expect the GDP terms in the following results to be significantly positive.

7.2.2 Overall Shipping Alliance Impact on Product-Level Trade

This section presents results from repeating the empirical tests in section 7.1.1 for trade in the container-dominated goods, estimating the impacts that all four major alliances as a group have had on product-level trade. Table 7.3 displays the results from these tests.

Amongst container-dominated goods the product-level empirical results are qualitatively different from the core empirical results. On a trade-level alliance market share is now expected to decrease bilateral trade flows, with a 10% increase in alliance controlled market share leading to a 1% reduction in bilateral trading flows. Amongst container dominated goods there is no statistically significant relationship between overall capacity and trade flows. Thus, there is no chance for technical benefits to outweigh the negative effect of alliance market dominance and this results implies that alliances are unambiguously trade inhibiting. On route-level there are no signs that alliances inhibit trade flows; while trade-level market share continues to significantly depress trade there is no statistically significant relationship between route-level capacity and bilateral trade.

Thus the general form of the results is similar for both the overall and product-level tests- on one geographic level alliances inhibit trade while on the other they do not- but the geographic levels are flipped; for product-level data the trade-level results suggest alliance inhibit bilateral trade while the route-level results have no indication that this is true. It is difficult to definitively state which method of measuring trade is superior; theoretically, product-level data are a better way to measure liner-shipping transported trade, as those data do not have the possibility of trade representing the effects of other transportation methods, but practically product-level data suffer from much larger data coverage and quality issues. Whichever weight one wishes to give theoretical concerns versus data issues, though, the general conclusion for the overall results is supported by these product-level empirical results; there is evidence in the product-level data that alliances are inhibiting trade but this conclusion does not exist for all specifications, suggesting that caution is warranted when drawing hard conclusions.

7.2.3 Product-Level Results by Alliance

This section presents results from repeating the empirical tests in 7.1.2 for product-level data, examining each major alliance separately. Table 7.4 presents product-level results from these empirical tests. On a trade-level these results are qualitatively similar to the core results, with no statistically significant relationship between 2M, G6, or O3 capacity and bilateral trade and a statistically significant negative relationship between CKYHE capacity and bilateral trade, supporting the same general conclusion that there is not strong evidence that alliances are in general utilizing market power.

On a route-level there are substantial differences between the core results and product-level results. 2M and O3 individual capacity continues to have no statistically significant effect on bilateral trade. However, for product-level data there is a positive relationship between CKYHE route-level capacity and bilateral trade, while there is a negative relationship between G6 capacity and bilateral trade. Thus, amongst product-level data there is a direct contradiction between the trade- and route-level results;

Table 7.4: Disaggregated Alliance Impacts on Product-Level Trade

Trade			Route				
Variable	Coefficient	Std. Err.	Variable	Coefficient	Std. Err.		
Intercept	-112.990**	5.302	Intercept	-113.205**	5.296		
lnDistance	39.788**	2.224	lnDistance	39.809**	2.219		
lnExportGDP	0.040	0.091	lnExportGDP	0.048	0.090		
lnImportGDP	0.643**	0.093	lnImportGDP	0.664**	0.093		
Capacity	-0.001	0.002	Capacity	0.000	0.002		
2MCapacity	-0.002	0.009	2MIndividualCapacity	0.013	0.018		
CKYHECapacity	-0.007**	0.002	CKYHEIndividualCapacity	0.018**	0.006		
G6Capacity	0.002	0.002	G6IndividualCapacity	-0.020*	0.008		
O3Capacity	-0.001	0.013	O3IndividualCapacity	-0.009	0.029		
			AllianceMarketShare	-0.116**	0.039		
N		887046	N		887046		
R ²		0.489	R ²		0.489		
F _(1667,885378)		507.877	F _(1668,885377)		507.57		
Significance levels :	† : 10%	* : 5%	** : 1%	Significance levels :	† : 10%	* : 5%	** : 1%

CKYHE could either be exercising market power or actually be encouraging trade depending on which geographic level one finds more plausible.

In summary, on a subset of goods that are likely to be carried almost exclusively on containers there are some significant differences in the empirical effect of liner shipping alliances, especially at the individual alliance level. However, the general conclusion from the core results is repeated; on a trade-level there are signs that alliances might be utilizing market power but this result is not entirely clear-cut and should be interpreted only carefully. This conclusion is reinforced by the alliance-level results, which do not contain any consistent evidence that alliances are able to utilize market power, suggesting that the negative overall effects may have been the result of aggregation issues.

7.3 Accounting for Missing Data

Due to reporting issues the bilateral trade data contains only about 85% of the exporter-importer-month combinations that would have been included if each nation in the sample reported full bilateral trade data for each month. It is possible that these missing data are not randomly distributed, in which case the empirical results may be

biased. This section repeats the earlier empirical tests using subsets of the data in which data coverage is more complete to ensure that empirical results in these subsets are not qualitatively different, finding that data coverage issues do not appear to have influenced the empirical conclusions.

These tests are carried out for three subsets of data, each of which uses a progressively smaller set of nations whose reporting coverage is more complete than the previous set. The first subset of data, denoted (1) in the following tables, excludes the twelve nations which do not report bilateral trade data. The second subset of data, denoted (2) in the following tables, excludes all of those non-reporting nations and further excludes six nations whose data coverage did not extend through the entirety of 2014. The final subset of data, denoted (3) in the following tables, includes only the eleven nations who reported data in every period in the sample. The third data subset does not include any data based on exports (as full data coverage for these nations makes it possible to use exclusively import-based data); the results from those tests thus also examine whether or not excluding export-based data qualitatively impacts the empirical results.

7.3.1 Overall Missing Data Results

Table 7.5 presents the results from repeating the tests from section 7.1.1 on the missing data subsets, with a legend summarizing the kinds of nations excluded in each subset. The “Percent Data” row reports what percentage of the hypothetical “perfectly reported” sample size is accounted for in each subset. For example, in the third subset had all eleven nations reported data for every trading partner in each month there would have been 5,000 exporter-importer-month data points; the actual third subset contains 4,991 exporter-importer-month data points, representing 99.9% of the perfectly reported data set. For ease of reading only the route-level results are reported; the trade-level results are quantitatively similar for all coefficients.

All three subsets produce quantitatively similar results for alliance effects, although no results are significant in the third subset (which is unsurprising given the

Table 7.5: Missing Data Overall Results

Variable	(1)	(2)	(3)
Intercept	-13.087**	-4.920**	-14.127**
lnDistance	-0.592	-4.937**	0.274
lnExportGDP	0.597**	0.562**	0.882**
lnImportGDP	1.738**	1.791**	1.468**
Capacity	0.011**	0.003	-0.002
AllianceMarketShare	-0.126**	-0.229**	-0.146
IndividualCapacity	-0.007	-0.002	0.008
N	43,082	28,174	4,991
Percent Data	96.4%	97.5%	99.9%
Non-Reporting Countries	Excluded	Excluded	Excluded
Non-2014 Reporting Countries	Included	Excluded	Excluded
Any Missing Months	Included	Included	Excluded
Significance levels :	† : 10%	* : 5%	** : 1%

small amount of data in that sample). These results broadly mirror the product-level results; on a trade-level alliances appear to inhibit trade, with higher trade-level alliance capacity leading to lower trade volumes. On a route-level there is no significant relationship between route-level capacity and trade flows. These results produce the same general interpretation as the product-level results; while they are qualitatively different from the overall results they support a similar conclusion about the potential market power of shipping alliances.

7.3.2 Missing Data Results by Alliance

This section presents results from repeating the empirical tests in section 7.1.2 for the missing data subsets, examining the economic impacts of each alliance separately. Table 7.6 presents trade-level results for these subsets of data, while table 7.7 presents route-level results for these subsets of data. In the latter table for the third subgroup it was not possible to estimate results for both the 2M and O3 alliances because amongst the eleven nations with full data coverage there is no route-level geographic or temporal variation between those two alliances (both serve the same sets of nation pairs in that group). The 2M coefficient is thus effectively the combined economic impact of both alliances.

The trade-level results are qualitatively similar to the overall results; for three

Table 7.6: Missing Data Trade-Level Alliance Results

Variable	(1)	(2)	(3)
Intercept	-13.266**	-4.971**	-14.756**
lnDistance	-0.487	-4.971**	0.955*
lnExportGDP	0.592**	0.560**	0.834**
lnImportGDP	1.730**	1.786**	1.421**
Capacity	0.011**	0.003	-0.017*
2MCapacity	0.004	-0.006	-0.014
CKYHECapacity	-0.011**	-0.018**	-0.023**
G6Capacity	0.002	0.002	0.017**
O3Capacity	-0.014	-0.001	0.017
N	43,082	28,174	4,991
Percent Data	96.4%	97.5%	99.9%
Non-Reporting Countries	Excluded	Excluded	Excluded
Non-2014 Reporting Countries	Included	Excluded	Excluded
Any Missing Months	Included	Included	Excluded
Significance levels :	† : 10%	* : 5%	** : 1%

out of the four major alliances (2M, G6, and O3) there is no sign that they inhibit trade and in the smallest subgroup G6 capacity is actually correlated with an increase in trade volume. Given the possibility of technical benefits from alliance formation, a result which implies that alliances do not exercise market power should be interpreted as a pro-alliance result. Mirroring the earlier conclusions, in each subgroup expansions of CKYHE capacity is associated with a decrease in bilateral trade, suggesting that the CKYHE alliance is exercising market power and inhibiting trade volumes.

The route-level results lack statistical significant; in these more limited subgroups there is no connection between any alliance's route-level capacity and bilateral trade flows for any alliance (although quantitatively the results are fairly similar). At the very least, however, there is nothing in these results which actively contradicts the earlier conclusions.

Overall, these missing data tests suggest the initial conclusions (if not the specific coefficients) are robust to concerns about missing data; there are signs that alliances are exercising market power but that result is not present in every empirical specification or geographic measure of capacity. The only alliance who specifically seems to exercise market power is CKYHE, with the other three major alliances having neutral or even positive effects on trade. The similarity of these results strongly

Table 7.7: Missing Data Route-Level Alliance Results

Variable	(1)	(2)	(3)
Intercept	-12.888**	-5.014**	-14.120**
lnDistance	-0.659	-4.886**	0.284
lnExportGDP	0.593**	0.561**	0.879**
lnImportGDP	1.734**	1.789**	1.466**
Capacity	0.011**	0.003	-0.002
AllianceMarketShare	-0.126**	-0.230**	-0.150
2MIndividualCapacity	-0.014	-0.013	0.036
CKYHEIndividualCapacity	-0.006	-0.006	-0.010
G6IndividualCapacity	-0.019	0.008	0.009
O3IndividualCapacity	0.032	0.009	—
N	43,082	28,174	4,991
Percent Data	96.4%	97.5%	99.9%
Non-Reporting Countries	Excluded	Excluded	Excluded
Non-2014 Reporting Countries	Included	Excluded	Excluded
Any Missing Months	Included	Included	Excluded
Significance levels :	† : 10%	* : 5%	** : 1%

suggests that data issues were not unduly impacted the earlier empirical conclusions.

7.4 Empirical Conclusion

A clear overall picture emerges from examining these empirical results. There are signs that alliances are exercising at least some market power; in every utilized specification there is a negative relationship between either trade-level alliance capacity or route-level alliance capacity and bilateral trading flows, which is entirely consistent with the idea that alliances utilize dominant market positions to extract economic rents and depress trade, suggesting that regulatory authorities are justified in maintaining some healthy skepticism towards shipping alliances.

However, these results are neither strong nor consistent; in every empirical test on some geographic scale shipping alliances are a net positive to trade volumes or at least not actively trade inhibiting. While the empirical results show signs of potential alliance market power they do not consistently exhibit the same effect in each test. It is difficult to justify significant regulatory responses in the face of such ambiguity; while concerns about shipping alliances are warranted, based on these results there is insufficient evidence to conclude that alliances are damaging to trade. Given the

potential that alliances are actually encouraging trade, the prudent course seems to be to monitor alliance behavior while avoiding hasty regulatory response.

This conclusion is reinforced by the empirical results which examine each alliance separately; it is only possible to conclude that one of the major alliances, CKYHE, is actively inhibiting trade. This suggests that the earlier negative effects may well have been driven by aggregation issues. For the vast majority of alliances (both in number and capacity volume) there are no signs that they are directly inhibiting trade, making it difficult to justify regulatory responses to their formation or expansion. While regulatory bodies may be justified in subjecting CKYHE itself to expanded scrutiny in light of these results, that is a far cry from justifying any fundamental changes in the regulatory structure for shipping alliances. While skepticism of alliances is fully justified, the relationship between shipping alliances and bilateral trade is not consistent enough to warrant strong regulatory responses. This is especially true given that, as the following chapter argues, the structure of modern liner shipping regulation is not particularly conducive to efficient regulatory decisions.

Chapter 8

THE FEASIBILITY OF REGULATING SHIPPING ALLIANCES

8.1 Optimal Liner Shipping Regulation given Uncertainty

The empirical results in Chapter 7 shows that there are some signs that alliances may be utilizing market power, but that this result is fairly ambiguous. It is difficult to determine which alliances may be utilizing market power; as established in Chapter 6 there is a surprising degree of similarity between the major alliances and the empirical results suggest that only one alliance (CKYHE) seems to consistently inhibit trade. Thus, while the empirical results seem to suggest that regulatory bodies might consider taking action against shipping alliances it is not obvious how they could distinguish a “good” alliance from a “bad” alliance in this context. This makes it difficult to justify regulatory action, as in effect regulatory bodies would be “shooting blind.”

The difficulty of establishing any hard-and-fast ways to distinguish between competitive and non-competitive alliances suggests that it is probably impossible to define effective rules for distinguishing when an alliance is acceptable or not, at least for the current system in which overall capacity is widely distributed amongst different alliances. Instead, it is more prudent for regulatory bodies to carefully monitor the behavior and results of shipping alliances as a way to prevent them from becoming anti-competitive, accepting that the sources of market power in this industry are subtle enough that attempting to detect them with formal standards is unlikely to be effective. That is, the results in Chapters 6 and 7 suggest that analyzing the *effect* of alliances is a much more effective way to manage regulatory policy.

One disadvantage of this strategy, however, is that it puts a substantial burden on the regulatory agencies themselves, which are tasked with monitoring and judging

competition concerns in real time rather than simply enforcing neutral rules. One obvious concern is thus whether or not regulatory agencies have the legal and practical abilities to manage this task. This chapter analyzes the legal history of liner shipping precisely to examine the question of how effectively regulations have been historically enforced and what those outcomes can teach us about the future potential of such regulation.

8.2 History of Liner Shipping Regulation

8.2.1 Historical Approaches to Regulating an International Industry

The correct regulatory approach to liner shipping has been an open question since the industry's formation in the 19th century. Much of the debate has turned on *how* to regulate the sector, or precisely what types of regulation are appropriate. Much less attention has been paid to the exact mechanics of how these hypothetical regulations would be implemented; there are many arguments about what the goals of regulation should be and considerably less attention paid to whether or not the institutional structure for accomplishing those goals actually exists.¹

This is a significant issue in liner shipping, as the history of regulatory efforts to control the industry casts doubt on the effectiveness of the existing regulatory structure. Sampson and Bloor (2007) provide a broad, institution based overview of these historical efforts, demonstrating that, historically, regulatory bodies have approached liner shipping regulation on two broad levels - national and international- neither one of which has been particularly effective. In an effort to examine how effectively liner shipping regulation have historically been implemented, this chapter presents a history of efforts to regulate the liner shipping industry and then analyzes current efforts to harmonize regulations across national boundaries.

1. As an aside, I believe this is a problem in many parts of the economics literature; too many researchers stop at establishing that some regulatory change -usually to correct a market failure- is theoretically possible, without properly examining exactly whether or not their preferred change is feasible to implement given technical or political limits on regulatory agencies.

This chapter analyzes regulation at both the international and national levels, first establishing that international regulation has been largely ineffective. This chapter then presents an analysis of national level regulation, establishing a brief history of the general national level approach to liner shipping regulation before analyzing what this history implies about the future of shipping regulation. This section on nation-level regulations focuses exclusively on regulation in the United States, the European Union, and China, comparing how their regulatory approaches have evolved over time. There are two reasons for restricting the analysis to these three nations.²

First, to a great extent these nations are the only nations with significant oceanic shipping regulation; most other nations have no serious anti-trust regulation on oceanic shipping firms which operate in their ports. More importantly, these three nations represent the centers of the major trades; effectively, all “East-West” traffic must land in at least one of their ports.³ Their regulation is thus incredibly significant to oceanic shipping; any regulation imposed by one member will significantly impact shipping firms’ decisions, while any regulation imposed by two or especially all of these nations is effectively internationally binding, as there is almost no feasible way for firms to avoid interacting with them as a group.

The fact that regulation in these three areas is virtually internationally binding is the heart of current liner shipping regulatory efforts. Modern regulation is increasingly emphasizing “sub-international” regulatory efforts which involve co-ordination between a handful of major nations rather than a broader coalition, based on the idea that agreement amongst a handful of economically vital nations are virtually identical to international regulation and considerably easier to implement. This chapter closes by analyzing the promise of this idea before cautioning that recent examples of regulatory

2. For simplicity, this chapter will treat the European Union as a “nation.”

3. While technically services could avoid all of these nations and still travel on the major trades -only carrying output from, say, Canada to Singapore- in practice this is not commercially feasible. That kind of specialized route almost certainly would not generate sufficient capacity demand to justify the fixed costs of vessel deployment, which is why exactly zero alliance services do not operate in at least one of these three nations, leaving the specialized routes to much smaller feeder services.

policy changes suggest that regulatory bodies may not have the institutional structure necessary to implement this plan.

8.2.2 Regulation at the International Level

This section presents a history of international regulation of the liner shipping sector. For the most part international regulation is irrelevant for anti-trust concerns in liner shipping; there are no international “anti-trust” laws for liner shipping, only a patchwork of frequently inconsistent national regulations analyzed in detail in the following section. Nevertheless, the evolution of international regulations is important for understanding liner shipping regulation because it illustrates *why* no international market structure laws exist and why such laws are extremely unlikely to ever exist. That is, a history of how the small body of international regulations that currently exist were created and how they have historically been enforced is an excellent way to demonstrate how unlikely it is that international laws will ever be an effective way to address competition concerns.

This section focuses on international laws as they relate to how nations can interact with *foreign* ships. That is, the focus is on the regulation nations can place on all ships that enter their ports, not just vessels registered in that nation, which is referred to as having that nation’s “flag” in maritime terminology. The last fifty or sixty years has seen the rise of “flagging out,” a practice in which many ships are registered in nations to which they have no tangible connection, frequently Panama, Liberia, the Marshall Islands, or Hong Kong.⁴ A majority of liner shipping vessels now carry one of these nations’ flags, often referred to as “flags of convenience,” and there is often little-to-no tangible connection left between the national origin of the shipping company and nation in which its vessels are registered (UNCTAD 2009). Thus, the most significant regulations are regulations which can apply to foreign-flagged vessels;

4. These nations are generally said to operate what are called “Open Registries,” which means one can register a vessel in that nation without having to demonstrate any commercial or physical connection to the nation itself.

regardless of how large a nation's domestic shipping industries may be, their ports are likely dominated by "foreign" vessels (The Economist 2009). Even those nations which still retain significant domestic-flagged fleets are limited in their ability to regulate these vessels, as there is nothing stopping their domestic firms from changing flags in response to any regulatory decisions (The Economist 2007).

While domestic laws are still important, they are important more for investment and tax terms than anything else (i.e., in the extent that they influence flag decisions). The ease with which shipping companies can avoid domestic regulations without impacting their ability to function in domestic markets severely weakens the regulatory power of domestic laws (Sletmo 2002). A nation's ability to restrict foreign vessels from operating in their ports is far more important; only those regulations that apply regardless of the vessel's flag are able to effectively "stick" to shipping firms. This left international negotiation facing a conundrum; on the one hand, only regulations that could apply to foreign vessels was likely to be truly significant. On the other hand, negotiators had a (frankly fully justified) concern that leaving each nation free to regulate every aspect of liner shipping firms' businesses and operations, regardless of the origin of their vessels, could lead to a Balkanization of the international trading system, as firms found it practically or even logically impossible to be in compliance with every nation's regulatory system.

The compromise that international law settled on, as set down in the United Nations "Law of the Sea," was to divide regulatory matters into two spheres; some regulations are reserved for "flag states" and some are reserved to "coastal states" (Stopford 1997). A flag state is the nation in which the ship is registered; a coastal state is the nation in whose waters the ship is currently operating (i.e., the port owner). By and large flag states control most significant technical and operational regulations, exemplifying the concept that a ship bearing a nation's flag is legally an extension of that nation's sovereign territory. The exceptions to this rule are internationally agreed upon conventions; these are a list of widely accepted treaties, generally overseen by the International Maritime Organization (IMO) and the International Labor Organization

(ILO), which set minimum legal standards that each nation's maritime policy must meet. Generally, the IMO handles technical standards such as ship specifications, safety regulations, etc., while the ILO handles labor issues such as maximum continuous hours on duty, minimum working age, etc.

Coastal states have the right to enforce any internationally agreed upon convention, regardless of the vessel's flag. For example, the United States cannot set minimum ship safety standards for any ships not flying a U.S. flag, nor can it enforce such standards of non-U.S. flagged ships which enter its ports, as those sorts of regulations are reserved for the ship's flag state. As a coastal state, however, the U.S. can enforce any safety conventions in effect for any ships which enter U.S. ports. While this system may sound relatively simple, in practice the precise definition and interpretation of these conventions can be incredibly complex (Roe 2002). Broadly, however, these conventions define the limits of domestic maritime regulation, as any regulation stricter than these standards could only be applied to domestically flagged ships and thus would be unlikely to be effective.

International regulation is thus only as effective as any convention which a significant majority of nations will agree upon. This process is both unlikely to produce strong regulation -as open registry nations are unwilling to sacrifice the advantages which allow them to draw shipowners to their nation- and, naturally, quite slow. By and large the process of adding new conventions has stopped; most major conventions were passed in the 1940-50s for the ILO and the 1960-1970s for the IMO and are only updated sporadically.⁵ For some time there was hope for what was called "Port-State Control," in which nations would control shipping firms by vigorously enforcing the pre-existing conventions to prevent shipping companies from "shopping around" regulatory regimes. However, there is little sign that this movement has accomplished

5. A full list of IMO conventions can be found at <http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/Default.aspx> and a full list of ILO conventions can be found at <http://www.ilo.org/global/standards/introduction-to-international-labour-standards/conventions-and-recommendations/lang-en/index.htm>.

much; the available evidence suggests that application of these laws is too inconsistent to be effective (Sampson and Bloor 2007).

In conclusion, there is little reason to believe that international regulation might be an effective way to resolve market structure concerns in liner shipping. Anti-trust concerns have never been handled at the international level; they are not covered in any IMO or ILO standard. A new convention would thus be necessary for any sort of international regulatory response; passage of such a convention would require agreement among a large majority of nations which is unlikely to be feasible given the wide variance in national competition laws. Even if such a convention could be reached, the historical difficulties in implementing and enforcing relatively straightforward regulation on issues like minimum ship safety regulations (which come with detailed technical standards) suggests that enforcement of more abstract market structure principles would be almost impossible.

8.2.3 Regulation at the National Level

The Scope of Regulation at the National Level

The following sections summarize the regulatory approach that each of the three major shipping centers -the U.S., E.U., and China- have taken with their anti-trust law regarding liner shipping. From this point on the analysis focuses on anti-trust law, ignoring other forms of maritime regulation such as safety and labor laws. It is difficult to draw any firm conclusions about non-anti-trust regulations due to the complex interplay of local, flag, and international regulatory standards which determine them. Ironically, the fact that international law does not cover anti-trust concerns makes the subject considerably simpler to evaluate; because there is no “Law of the Sea” regarding competition law, coastal states are free to decide if they will approve or reject the structure of a specific shipping firm. In effect a shipping firm must be in compliance with a nation’s anti-trust laws to operate from any of its ports. For example, to operate a service in the U.S., a shipping firm must have gained operational approval

from the Federal Maritime Commission (FMC), which in turn requires compliance with U.S. antitrust law.

Each nation's anti-trust laws apply only to the parts of a shipping firm's operations which interact with their ports; nations do not have the ability to police the industrial structure of the parts of a firm's operations which operate exclusively in other waters. For example, if the U.S. banned shipping alliances, firms which operated in the U.S. could still form alliances as long as that co-operation was only on services which did not enter U.S. waters, such as between Europe and Asia. If the firm's U.S. operations were in compliance with U.S. law then the FMC could not withhold operational approval based on the structure of the firm's behavior elsewhere.⁶

The United States

Market structure concerns in liner shipping have existed for almost as long as steam powered ships have been a viable method for carrying cargo. The early years of the liner shipping industry were marked by instability and low profitability, which led many firms to co-operate in the hopes of avoiding "destructive competition." It is generally accepted that the first instance of co-operation in the liner shipping industry was the Calcutta Conference, a collaboration amongst British firms on routes between India and the U.K. which began in 1875. Similar conferences quickly became the standard operating method in the liner shipping industry. These newly formed conferences coordinated prices and vigorously fought outside entrants to preserve market share, an approach they would maintain for over a hundred years after their initial formation (Morton 1997). The widespread and public nature of shipping co-operation naturally put the industry in the crosshairs of many early anti-trust crusaders. However, for

6. In reality this is slightly more complex than it seems; while nations cannot directly tie approval to non-domestic activities, nations will sometimes make approval of firm's operations conditional on worldwide behavior. For example, the FMC is technically obligated to consider the "worldwide" implications of an activity before approving it, so that it might consider whether or not a firm's behavior is impacting U.S. trade on non-U.S. routes. There is no practical way to measure these impacts, however, and to the best of my knowledge no regulatory agency has ever tried to block domestic entry based on non-domestic activity.

the most part the shipping industry was left unregulated as it was widely believed that maintaining a domestic shipping industry was important for military reasons and lawmakers were willing to ignore co-operation that would have been illegal in other industries in the name of preserving their domestic shipping industry.

The United States is one of the rare exceptions to this trend, with a regulatory policy towards maritime shipping that began in 1916. U.S. maritime regulatory policy began as a compromise; conference activity was blatantly illegal under the Sherman Act, but U.S. lawmakers wanted to preserve their domestic industry and believed that it would collapse without some sort of anti-trust exemption (Sagers 2006). In an effort to balance preserving the domestic industry with anti-trust concerns lawmakers passed the Shipping Act of 1916, which made conferences legal but put them under government oversight. More significantly, the Shipping Act required all conferences on U.S. routes to be “open,” which meant they were obligated to accept new entrants as long as those entrants complied with the conference’s requirements. This “openness” obligation is the most significant historical difference between U.S. and international regulation; in other nations “closed” conferences, which decided their membership internally, were the norm.

Beyond some legal wrangling this system remained the U.S. standard for most of the 20th century. In 1984 the Shipping Act was amended to encourage competition. In response to discontent with the new system in 1998 the Ocean Shipping Reform Act (OSRA) was passed. Each of these bills had significant impacts on U.S. maritime trade, especially in regards to the Federal Maritime Commission’s relationship with shipping firms, which has steadily moved from an active overseer to a more passive agency which periodically checks for infractions. Rather than get bogged down in the specifics of either bill, however -which in many cases are extremely technical details about filing periods and which types of firms qualify as a “maritime firm”- it is sufficient to focus on what was easily the most significant change; the legal acceptance and then active encouragement of independent service contracts.

As mentioned in Chapter 2, service contracts are agreements between a specific

shipping firm and a specific shipper to carry goods at an agreed upon rate and shipping schedule. Historically, such contracts were illegal out of concern that they would block smaller shippers from being able to trade internationally; instead regulatory bodies enforced the concept of “common carriage,” under which liner firms were required to accept all cargo neutrally for announced prices. The 1984 Shipping Act made service contracts legal, which led to a massive explosion in their popularity. However, two provisions in that act restricted the value of service contracts. First, such a contract had to be publicly announced, which allowed conferences to monitor if their member firms were using them. Secondly, in an effort to preserve common carriage, service contracts had a “me-too” provision in which any “similar” shipper was entitled to demand a contract with identical terms. In the process of determining whether or not a shipper was “similar” the shipping firm would be forced to divulge commercially sensitive information (such as the amount shipped, price, and destination) to their customer’s rivals, which meant many shippers were leery about entering into service contracts (Friedman and Devierno 1984).

The awkwardness of this system and growing pressure for reform eventually lead to the Ocean Shipping Reform Act, which largely ended common carriage. Under OSRA, conferences are legally barred from interfering with their member firms’ service contracts and service contract details are strictly confidential. The vast bulk of international trade is now carried out under one of these contracts. This has largely robbed conferences of any ability to enforce conference prices, as shipping firms are now able and obviously willing to deviate from the conference price schedules whenever they feel it is profitable to do so (OECD 2002). This legal change has greatly encouraged the spread of alliances; a purely technical agreement, in which the firms pool capacity while keeping commercial interactions separate is not impacted by how each firm finds or prices their cargo. Despite some further efforts to do away with the anti-trust exemption for conferences entirely -specifically the 2001 Free Market Antitrust Immunity Reform Act- conferences remain legal in the United States. However, their ability to function has been completely destroyed by regulatory restrictions on their ability to

police their member firms' behavior. In effect the U.S. ended the conference system not by making conferences illegal but by (perhaps inadvertently) robbing conferences of any ability to protect themselves from competitive incentives to deviate from the conference structure.

The European Union

For the E.U., liner shipping regulation began with the formation of the union itself; before that liner shipping companies were regulated by a patchwork of national regulations which are beyond the scope of this analysis to cover. On average though, these regulations matched the general standard of the time in that they were loose or non-existent in almost all countries, largely legalizing anti-competitive co-operation and relying on liner firms to self-police. There was thus considerable concern when the E.U. was formed about the extent to which its competition rules would apply to liner shipping. Liner shipping is a very important industry in many E.U. nations and the E.U. anti-trust regulations were much stricter than the national regulation they might replace. Years of concern were put to rest when the E.U. passed regulation 4056/86, which granted liner shipping firms a block exemption from E.U. anti-trust laws.

This exemption has been called the “most generous in history,” as it legalized virtually every conference restriction on firm member activity and contained no sunset provision, making it theoretically permanent (Phang 2009). The breadth of exemption 4056/86 led to continual legal conflict throughout the 1990s, as liner shipping companies sought to interpret their block exemption to cover nearly all aspects of their behavior while the E.U. attempted to interpret it to cover only port-to-port trade. The E.U. won most of these confrontations, such that the value of the conference block exemption slowly decayed as it was continually re-interpreted to cover a smaller and smaller subset of conference behavior (Benacchio, Ferrari, and Musso 2007).

Despite these small changes in the size of the exemption, for the most part liner shipping was immune to standard anti-trust law, a fact that created growing distaste for the current system. When discussing a settlement between a shipping conference

and the E.U., Mario Monti, the E.U. Commissioner for Competitive Policy, remarked that the agreement was “the most competitive outcome that can be achieved under the current legal regime,” a statement that clearly emphasizes the frustration many were feeling with regulation 4056/86 (European Commission 2003). This distaste led to growing legal efforts to reform the current system. As with many aspects of E.U. law, the specific legal process for this reform was quite complex and a full summary is outside the scope of this work.⁷ It is enough to note the results; in 2006 the E.U. agreed to repeal regulation 4056/86 and in 2008 this repeal went into effect. While liner shipping firms in the E.U. are still allowed to co-ordinate services in the form of alliances or consortia, they are otherwise now covered under standard anti-trust law, formally outlawing any effort to co-ordinate prices or restrict entry into the market. The E.U. has the strictest anti-trust laws on liner shipping, as that jurisdiction is the closest in the world to covering liner firms under the same anti-trust laws which apply to other industries.

China

This section presents a history of liner shipping regulation in China.⁸ Historically, anti-trust law in China has worked very differently than similar regulations in the U.S. or the E.U., as China only began enforcing a formal competition law in 2008 (Wang and Zhang 2007). Before that competition law was defined on a sector-by-sector basis and thus there was no need for shipping firms to seek an exemption, as there was no anti-trust law to be exempted from. It is still unclear to what extent this law will impact liner shipping; there is a general concern that it may be used as a weapon to target politically unfavored (especially foreign) firms while propping up politically favored

7. Both Phang (2009) and Benacchio, Ferrari, and Musso (2007) contain complete summaries of this process.

8. This section focuses specifically on mainland China. It thus explicitly does not cover liner shipping regulation in Hong Kong. As a special legal area, Hong Kong has its own shipping regulations which are entirely distinct from the mainland’s regulations. For example, Hong Kong recently imposed competition rules that would render most alliances illegal, and the principal concern expressed about them was that such rules would divert traffic to *other* Chinese ports (Knowler 2015).

(especially state owned) firms (Gough, Buckley, and Wingfield 2014). This possibility is extremely significant when considering the future of liner shipping regulation.

China's history of liner shipping regulation is, perhaps unsurprisingly, quite short. The history of China's maritime policy largely mirrors China's transition towards a market economy; up to 1978 all shipping firms in China were fully government owned and operated. Only by 1985 were foreign shipping firms able to enter the market in the form of joint ventures and only by 1990 could they freely operate in China (Liu 2010). Ever since liberalization China's regulatory policies regarding shipping companies have been extremely liberal. To operate in China a liner firm need to meet a small number of technical requirements, none of which are unusual by international standards, and gain approval from the relevant regulatory agency. This second step is the more significant barrier and it makes no *per se* distinction between individual firms or collaborative services like conferences or alliances; both forms of organization need to submit the same core documentation, with the only distinction being that collaborative services must submit some information for all of its member firms (Li et al. 2005). Technically this review stage should serve as a form of competition policy, as the level of market competition is a factor that regulatory agencies are instructed to consider when deciding whether or not to approve a firm's entry. Historically, however, there is no sign that this has proven to be a significant stumbling block; for the most part international firms have not struggled to gain access to Chinese ports regardless of their market structure.

It is thus difficult to analyze Chinese maritime regulation, as many of the particulars of its maritime policy turn on the attitudes and beliefs of regulatory authorities rather than on a body of established law. Perhaps the best summary of China's regulatory policy is to note that in the aftermath of Chinese regulatory agencies vetoing the proposed P3 alliance -an event covered in more detail in section 8.3.1- multiple authors suggested that this represented a fundamental change in the global regulatory landscape (Agence France-Presse 2014; Tejada 2014). This is despite the fact that there had been no change in Chinese law and that the veto was in principal entirely

consistent with laws that were at that point over ten years old. This incident illustrates the fact that while China's current system is quite permissive, this permissiveness is entirely conditional and could easily change if the political situation in China changes.

8.3 The Future of Liner Shipping Regulation

8.3.1 "Supra-National" Regulation

The above section is a summary of the current state of liner shipping regulation. In terms of competition concerns there is no settled international law, nor is there any reason to believe that international regulation, as it has been traditionally implemented, would be either feasible or effective. Competition law is thus left to individual nations, who set their own standards as coastal states. At least thus far this system has performed reasonably well; while competition law in liner shipping is still riddled with exemptions the general arc has been towards a more competitive system. Nevertheless, the current fully national system suffers from a number of significant issues.

For all the problems of international law, there was a reason behind the concept that nations should be limited in how they can restrict international shipping. The "Law of the Sea" is an important buffer against the very real risk that the international trading system could break down due to each country imposing its own set of regulations. It enshrines in international law an admirable principal of conditional openness to maritime trade, in which any responsible (i.e., compliant with universal standards) shipping firm can carry goods between any two ports without undo restriction. In the area of competition law the world faces the very real possibility that national policy can undermine this standard, creating a system in which each nation's competition law is so different that firms will have to adopt inefficient or convoluted business structures to comply with all of them. Or, worse, a system in which each nation uses its competition laws to intervene in the market on behalf of their domestic shipping firms, an outcome that would severely hamper the international trading system. While this has not yet occurred, it will remain a danger for as long as the system remains fully national in scope.

On the flip side, there is a real possibility that national regulators may be unable to properly regulate larger international shipping firms due to the physical and legal mobility inherent in the shipping industry. While nations can control the competition policy within their own waters, this may be of limited value in a globalized industry in which firms can remain in compliance with domestic laws and still structure themselves in anti-competitive ways internationally. For example, if the U.S. banned shipping alliances firms would still be able to form them on other routes. This cooperation on other routes would naturally impact domestic trade; by definition a firm coordinating its' sailings from Asia to Europe with other firms will impact its' decisions on sailings to the U.S., even if it operates as a fully independent business on those routes. In this example there is no wrong-doing; it explicitly assumes that firms are fully abiding by U.S. regulations. When one considers the possibility that firms might actively seek to avoid domestic regulation by utilizing the international nature of their operations it becomes clear why national regulation may not be up to the task of regulating this industry. Concerns like this have grown widespread enough that one of the commissioners of the FMC has publically spoken about the risk of shipping alliances acting as "supra-national" forces (Dupin 2015).

What all of this implies is that the future of liner shipping regulation is likely to depend heavily on the *interaction* of "national level" regulations, especially the policies of the three major shipping sectors. The internationally mobile nature of shipping firms means that regulatory firms must take other nations' regulations into account when determining their own regulatory policies. This means regulations can "spill over;" for example, one of the principal arguments for ending conference exemption in the E.U. was that conferences could no longer reliably enforce their tariff prices due to service contracts (Benacchio, Ferrari, and Musso 2007). The widespread use of service contracts was itself the result of OSRA in the United States; in this way a loosening of U.S. regulations contributed directly to a still stronger loosening of E.U. regulations due to the interconnected nature of the industry (OECD 2002).

Beyond simply the need for regulatory agencies to account for the larger international regulatory context, co-operation between a small number of national regulatory agencies may well be a solution to the issues posed by the international nature of the shipping industry. As mentioned before, any regulation that was enforced in at least two or all three of the major shipping centers would be as good as international law. Thus, regulatory co-operation between those three nations could accomplish virtually the same level of widespread applicability as formal international law while keeping the number of parties involved small enough to make reaching consensus feasible, avoiding the pitfalls of formal international law.

There is great potential in this approach; as regulatory agencies are fast to point out, co-operation may allow regulatory agencies to think and act “globally” by making decisions based on the global (rather than national) impact of their competition decisions and by enforcing rules in a way that prevents shipping companies from avoiding regulations by simply shuffling their operations around. While regulatory agencies are unlikely to trumpet this fact, another beneficial effect of this sort of regulatory decision-making would be to harmonize regulations across nations, as efforts to coordinate will naturally entail regulatory policies slowly becoming more similar across nations. While the value of this tendency is obviously conditional of the quality of the changes to regulation, all else equal such harmonization and the reduction of potential compliance issues is beneficial.

Indeed, regulatory agencies are already in the early stages of attempting to implement higher levels of co-operation. Thus far regulatory agencies have held two “Global Regulatory Summits,” the first in 2013 and the second in 2015. Both meetings were attended by representatives from the three major shipping centers for the stated purpose of sharing information and discussing regulatory collaboration (Federal Maritime Commission 2013). There was little effort to hide the fact that competition laws and shipping alliances are the impetus for these gatherings; for example, before the most recent meeting the European Commission bluntly stated that “discussions

are expected on the global trend towards increased cooperation and market consolidation in liner shipping” (Bonney 2015). There is every reason to believe that the trend toward greater co-operation in the liner shipping sector may well be matched by a similar trend of greater co-operation between liner shipping regulators, a trend that could potentially deliver significantly more effective regulation.

8.3.2 The Veto of the P3 Alliance

Precisely because this approach may well be the future of maritime regulatory policy it is important to carefully evaluate the merits and, more importantly, the potential issues in this approach. Regulatory history is littered with ideas that seemed sound in principal but failed once they were actually attempted. Unfortunately, this sort of “supra-national” regulation is at this point entirely theoretical; there are not any specific regulations to evaluate yet. Still, there was recently a major regulatory event which involved all three major shipping centers and competition policy; the attempted formation and eventual veto of the Pacific Three alliance. While technically no direct regulatory collaboration occurred during this process, the story of P3’s eventual veto is an excellent illustration of some of the issues that any effective regulatory collaboration will have to find a way to overcome.

To briefly summarize the events in question: in the summer of 2013 the three largest shipping firms in the world, Maersk, MSC, and CMA-CGM announced plans to form a strategic alliance which was formally named “Pacific Three” and quickly dubbed P3. As the name implies the alliance was meant to be oriented towards Asia, especially in the Europe-Asia trade in which the alliance would have controlled over 40% of capacity (Bowman 2013). Reaction to the formation of this alliance was immediate, with many shippers and other shipping firms expressing concern or outright fear at the potential market power of this alliance (Giles, Waha, and Daniels 2014; Raun 2013). Regulatory agencies had equally dramatic responses; the very first “Global Regulatory Summit” was held in direct response to the potential P3 alliance (Alphaliner 2013c). Despite those concerns, the FMC approved the alliance fairly quickly by a vote of

4-1 and after some deliberation European competition authorities followed suit and approved the alliance (Alphaliner 2014).

However, in late 2014 China unexpectedly vetoed P3, citing the potential for market power and their belief that the P3 alliance was structured in a way which made it “essentially different” from other shipping alliances (Manoj 2014). This veto came as a surprise, as it was only the second time China had ever vetoed a merger or joint venture in any industry on competition grounds (Bilby 2014). In the aftermath of the veto, the three carriers quickly cancelled the planned alliance; given P3’s Pacific focus it would have been unworkable without access to Chinese ports. As each carrier had already built some of its routing and business plans around the concept of this alliance they were left scrambling to come up with new arrangements that would enable them to meet their shipping needs.⁹ Ultimately, Maersk and MSC formed 2M, while CMA CGM, the “left over” member, quickly scrambled into a new arrangement with shipping firms UASC and CSCL to form Ocean Three; both alliances were quickly approved by all three major shipping centers. Opinions on the motives behind and wisdom of China’s veto remain split; some have accused them of intervening only to protect their domestic firms (Agence France-Presse 2014; Bonney 2014). Others, especially those representing shipper interests, have applauded the decisions as a wise effort to preserve sufficient market competition (Brautlecht 2014).

Regardless of the merits of China’s decision, however, the manner in which this outcome was reached raises questions about the viability of regulatory collaboration. In the aftermath of the veto there were some efforts to spin the result as a triumph of regulatory collaboration, usually taking the tact that China had wisely saved the other two agencies from themselves (Szakonyi 2014). However, this cannot obscure the fact that both the U.S. and the E.U. initially *approved* the alliance; they clearly did not view it as competition infringing. While China’s trade would have been the

9. This planning is likely one of the reasons the alliance was vetoed; when reading statements from regulatory authorities one can sense a distinctly peeved sense that they did not appreciate the firms’ presumption of regulatory approval.

most impacted by P3, as it was the center of the alliance's proposed network, U.S. and E.U. would also have been heavily impacted. There is no reason to believe those two nation's regulatory bodies treated this issue more lightly when they approved P3. However, that approval was apparently not enough to convince Chinese authorities to follow suit, which strongly suggests that commitment to the idea of harmonization may not be particularly deep; at the very least in this instance it was not enough to influence the outcome.

More troubling, it is hard to avoid the conclusion that national concerns played a significant role in each stage of this process. While to the best of my knowledge no author has mentioned the possibility, it is worth noting that the European nature of P3 may well have played a role in securing approval for P3 from European regulators. Certainly it meant that E.U. regulators did not have to balance domestic concerns with anti-trust concerns. As has been more widely discussed, it is hard to believe that China's veto decision was not at least partially driven by concerns over their domestic shipping industry, which is state-owned and has been badly struggling in recent years (Bhattacharya 2014). The formation of P3 would have created an alliance system in which China Shipping Container Lines (CSCL), one of the two major state owned shipping firms in China, would not have been a member of any major alliance but would have had to compete with other large firms who would mostly have been in alliances. While there is no direct evidence that China's decision was based on domestic concerns, had P3 been "P4," with CSCL as a fourth member, it seems very unlikely that it would have been vetoed.

It is notable that in the aftermath of the veto when China was presented with the chance to approve a new alliance structure which had the two major state-owned Chinese firms included in the major alliances -COSCO in CKYHE and CSCL in Ocean Three- they quickly approved it, despite the fact that arguably the new 2M system was not dramatically different from what the P3 system would have been. In short, while it is difficult to prove anything definitively, there are signs throughout this process that regulatory agencies are to some extent protecting their "home turf," using competition

policy to defend their domestic shipping industries.¹⁰

In conclusion, the possibilities of regulatory collaboration are legitimately exciting; they have the potential to create a more efficient and harmonized regulatory system than has ever existed. This may finally create an “international” regulatory system that can simultaneously be both fairly applied and actually effective. However, it is a system that puts significant demands on the good faith and commitment of major shipping center’s regulatory bodies, as each one preserves the ability to interfere with any collaborative effort and each one has incentives to do so in the name of domestic firms. An important and frankly largely ignored question is thus whether or not each nation has the will to avoid these temptations and attempt actual collaborative policy. The effective working of this system requires that *each* of the three major shipping centers possess sufficient “political will” to implement joint policy. It is unclear if such political will truly exists in any of the three major shipping centers, let alone all three, and if they cannot commit to the system then it is likely that this idea will join a long history of excellent ideas that could not survive contact with the ugly reality that regulatory policy must live in its political context.

10. Note that the FMC has no particular incentive to use competition policy in this manner, as the U.S. relies almost exclusively on foreign shipping and thus the FMC’s major concern is to preserve customer *access* to shipping services, rather than any domestic shipping industry. Arguably the FMC has the best incentives of any regulatory body, as their interest largely align with that of actual shippers rather than any domestic industry.

Chapter 9

POLICY IMPLICATIONS AND CONCLUSION

The liner shipping industry is notoriously difficult to analyze, which explains why a considerable body of research examining the industry has yielded very few definitive conclusions. The sheer geographical and cultural breadth of international shipping makes it exceedingly difficult to even keep track of every part of the industry, let alone carefully analyze the industry. Rarely is the almost unbelievable *scale* of the global trading system made more obvious than when one is forced to appreciate the complexity behind the seemingly basic act of carrying output from port-to-port. Analysis is further complicated by the industries' long traditions of unusually high levels of co-operation and extreme secrecy, leaving analysts attempting to examine an industry which has no obvious industrial precedent using data which can, at best, be described as "incomplete."

Researchers and even government agencies have thus historically had to rely on *ad hoc* methodologies, utilizing whatever information and data they can find while accepting the limitations of such sources. Nothing illustrates these limitations better than noting that this research represents one of the first serious time series analysis in this literature; previous empirical work has been almost entirely cross sectional due to data limitations. Despite these difficulties, this research has produced valuable theoretical and empirical results utilizing a data set that is, to the best of my knowledge, the most complete measurement of the liner shipping sector ever used in formal research.

This analysis of the economic impacts of liner shipping establishes that it is entirely appropriate to be wary of liner shipping alliances. Theoretically, it is possible that alliances are no more than efforts to attain market power; given fixed costs and routing issues such "pure market power" alliances may well be stable in a way that

they would not be in a more traditionally structured industry. Empirically, there are signs that alliances inhibit trade in a manner entirely consistent with the existence of market power, a result which is particularly true for the CKYHE alliance.

Nevertheless, I submit that these results on net support a regulatory strategy of “wait and see.” The theoretical works suggests that the same unique structures that might allow the existence of stable trade inhibiting alliances also allow for the possibility of trade enhancing alliances. Furthermore, many of the assumptions in that theoretical work skewed the results in an anti-alliance direction; for example, a more formal examination of defection by member firms could potentially have undercut trade inhibiting alliances. The empirical results suggest that if alliances lead to expansions of capacity they may still ultimately be trade enhancing even if they utilize some market power. Furthermore, there is no evidence that most alliances exhibit market power, which suggests that the overall negative effects may be a result of aggregation issues. Given that the empirical results show no evidence that the 2M, G6, or O3 alliances utilize market power it is difficult to justify any strong regulatory actions against alliances.

As is always the case with economic regulation some humility is warranted. The track record of liner shipping regulation is not impressive on any level; in the absence of relatively strong indications that alliances are truly trade inhibiting it is difficult to believe that we can trust the existing regulatory decision making structure to correctly identify alliances which utilize market power, especially given the lack of any obvious standard to do so. There is a world of difference between scrutiny and actual action. More research would be necessary to justify any large intervention in the liner shipping sector.

In terms of the broader economic literature, liner shipping is an extremely important topic. I hope that, if nothing else, this thesis has established oceanic shipping’s practical significance to the modern global economy. Oceanic shipping is an important part of the globalized economy and becomes more important every year as trade increasingly orients itself to longer distance movements. However, liner shipping is also

significant for trade economics itself and, more broadly, it represents the sort of area in which trade economists should spend more time researching. I believe that work such as this, examining the intersection of other branches of economics (such as industrial organization or transportation) and international trade, should be an important part of modern trade research.

As far back as Ricardo the international trade literature has focused heavily on the goods side of trade, with an emphasis on what determines the pricing, quantity, and especially the composition of international trade and often simplifying or ignoring other aspects of economic decision-making. Considerations such as market structure or transportation issues (along with a host of other concerns) were either ignored or dealt with using highly simplified abstractions like iceberg costs. I believe it is time for scholars to begin examining how our results will (or, perhaps, will not) change if those abstractions are relaxed. This conclusion is not a judgement of previous scholars; the international trade literature has made enormous progress with this good-oriented focus and in many cases the simplifying assumptions used were a perfectly reasonable effort to stay focused on the main issues. Furthermore, in many cases data constraints made empirical tests related to these issues infeasible.

However, it is becoming increasingly feasible to overcome these data constraints as the quality and breadth of data grows stronger every year. At the same time, research oriented toward the “good” component of trade has hit something of a wall. A great deal of contemporary trade research expends huge amounts of effort to slightly improve upon previous results; this does not seem like a profitable use of time. I am arguing that we should revisit some of our simplifying assumptions not out of failure but out of success; the literature has moved far enough with a single-minded focus on “goods” that it has hit the point of diminishing returns. It is only economical in that case to spend at least some time examining whether or not some of the avenues that were previously not worth exploring may prove to be a more efficient way to advance our knowledge.

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Appendix A

GLOSSARY

Below are definitions for all of the relevant nautical terminology used in this thesis. These definitions can vary from source to source; this glossary should be taken as a summary of how these terms are used in this work rather than as general definitions.

1. Cabbotage

- Cabbotage is intra-national trade that involves vessels which only operate between domestic ports (for example, a route that exclusively transports goods from Oakland to Houston would be a cabbotage trade).
- The cabbotage market is highly regulated in most countries and generally competition from international firms is highly restricted or outright banned. In the U.S., for example, the Jones Act requires that all cabbotage vessels be U.S. made, U.S. flagged, and U.S. crewed, which restricts the trade to a very small subset of vessels which are mostly owned by U.S. firms.

2. Common Carriage

- Common carriage is the principle that liner firms should not distinguish between different sources of cargo, instead carrying any output brought to them under common standards without differentiating between customers.
- Common carriage was the historical standard for liner shipping, but the rise of service contracts has largely ended it in the modern industry, in which personally negotiated rates between specific shippers and shipping firms are the industry standard.

3. Flag

- Every vessel which is involved in international trade has a “flag” from a sovereign nation which officially designates them as belonging to that nation’s maritime fleet. A vessel’s flag essentially registers that vessel under the regulatory regime of the flag nation.
- While there some basic international regulations on vessel quality, code frequencies, and environmental pollution, a flag effectively dictates labor, wage, and safety regulations.

4. Intermodal

- Intermodal transportation is shipping that involves directly transferring the cargo over multiple modes of transportation. In liner shipping the most frequent version of intermodal shipping involves taking containers directly from the vessel and loading them directly onto trucks or trains.

5. Ocean Shipping Reform Act (OSRA)

- The Ocean Shipping Reform Act (OSRA) was a major reform of the U.S. shipping regulatory system in 1998. OSRA left conferences technically legal but forbade the conferences from restricting the ability of its member firms to undertake private service contracts with no public notice.
- This effectively ended the conference system as it allowed riskless deviation from conference pricing and quantity restrictions.

6. Open Registry

- A nation operates an “open registry” if it does not require a registering vessel or owner to have any tangible connection to the nation in question in order to gain that nation’s flag. For example, many vessels are registered to Panama’s fleet despite not having Panamanian owners, operators, or crew.
- Open registries are generally viewed as a way to avoid labor market regulations; they require yearly payments for registration but usually have very lax safety and labor regulations.

7. Panamax

- Panamax is a set of ship specifications that represents the largest possible vessel which can travel through the Panama Canal; any ships which exceeds this limit in any dimensions will be physically unable to cross the canal.
- “Post-Panamax” ships are ships which are beyond this limit and thus whose potential route options are relatively limited (as it takes a substantial effort for them to transition from the Atlantic to the Pacific or vice versa).

8. Pendulum

- A “pendulum” is a type of service which crosses more than one major trade and often does not directly circle back from one trade to another. For example, a route which moved from Europe to Asia to North America to Europe is a pendulum, crossing two major trade routes and not directly carrying output from either Asia to Europe or North America to Asia.

9. Regulation 4056/86

- Regulation 4056/86 was an EU regulation that exempted liner shipping conferences from standard anti-trust regulations, allowing the conference system to function without anti-trust implications. In 2008 EU lawmakers repealing regulation 4056/86, effectively rendering the conference system at the time illegal. This led to the end of the conference system on EU routes and effectively ended the conference system as a globally significant force.

10. Route

- A “route” is a specific link or set of links that connect nations- for example, all of the services that connect the U.S. directly to Singapore are a route. Defined in this way there are literally thousands of routes in the modern trading system, linking every non-landlocked nation to every other non-landlocked nation.

11. Service Contracts

- Service contracts are private agreements between shippers and shipping firms which involves the shipper pre-purchasing a certain amount of capacity on a specific route each month. The shipper gets guaranteed service, while the shipping firm is able to better ensure full utilization and smooth the variance in shipping demand.

12. Shippers

- A “shipper” refers to a firm who wishes to have an item shipped from one location to another. They are the customers or demand side in the liner shipping industry.

13. Shipping Firms

- Shipping firms are firms who actually operate vessels and carry output; they are the supply side of the liner shipping industry.

14. Slot-Sharing

- Slot-sharing occurs when one shipping firm purchases a certain amount of space (“slots” of TEUs) on another firm’s vessel. This is a commonly used way for shipping firms to operate along or enhance their operations along a route or trade without the expense of putting a new vessel into operation.
- In a slot-sharing arrangement the purchasing firm is effectively identical to a shipper.

15. String

- A “string” is a subsection of a pendulum that represents the part of the pendulum that operates along a specific major trade. In the previous example, that pendulum contains string linking Europe-Asia, Asia-North America, and North America-Europe, with the pendulum being the combination of those three string.

16. TEU

- TEU stands for “Twenty Foot Equivalent Unit,” and represents the space occupied by a twenty-foot container. Traditionally, this container is exactly twenty feet long and eight feet wide. The height of different containers can vary, but are usually around eight feet.
- A TEU is the standard unit of capacity measurement in liner shipping, even for ships which carry larger containers (for example, a larger forty-foot container is generally thought of as 2 TEUs).
- Ship sizes are usually given in terms of the number of TEUs the ship can carry rather than their physical dimensions; two ships that can carry 6,000 TEUs are often treated as equivalent even though it is entirely possible that they are substantially different in terms of physical size.

17. Trade

- A “trade” is a general term for a larger physical area of international exchange that includes a number of different nations and individual routes. Trades are usually, but not always, defined by all trade across a specific ocean; the Transpacific trade, for example, is used to refer to all of the trade that crosses the Pacific Ocean.
- There are three major trades; Europe-North America (Transatlantic), Europe-Far East (denoting all trade from Europe, the Middle East, and Africa to Asia), and Asia- North America (Transpacific)

18. Transshipment

- Transshipment occurs when a container is transferred from one vessel to another before reaching its final destination (so that its trip from the port it was shipped from to the port it is being shipped to includes at least one intermediate stop).
- Transshipment is the dominate method of transportation in a hub-and-spoke system, with products generally being transferred from larger international vessels to smaller regional vessels in some hub port.