Ex Tridens Mercatus[*]- Sea-power and Maritime Trade in the Age of Globalization[†]

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[*] "from seapower commerce"
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Abstract

This paper tests an implication of Kindleberger's hypothesis that a hegemon can provide increased commercial and financial stability. Specifically, we measure the influence of naval power projections on global trade during the latter 19th and early 20th centuries. We use archival original-source data on navies for England, France, the United States and Germany, capturing longitudinal measures of ship deployment, tonnage, and ship personnel. First we develop a model of naval power, and demonstrate that the navies of England and France in particular responded heavily to each other. We then use our estimates of naval power projected around the world by England, France and the U.S. to measure their effects on bilateral trade using a panel-data gravity model. Results suggest that both the English and American navies were positive forces for global commerce. The French navy on the other hand bolstered its own trade at the expense of other nations' trade. Our results conform with the suggested naval strategies of the time, and demonstrate that military buildups can be positive or negative for commerce, depending on their use.

- *Keywords*: trade, arms race, 19th century, war, naval power
- *JEL Codes*: F1, F5, N4, N7

1 Introduction

The late 19th century witnessed an unprecedented rise in international commerce (ORourke and Williamson 2002). Economic historians are still trying to understand the precise nature of this globalization - was it due to transport technologies (Harley 1988), or the gold standard (Lopez-Cordova and Meissner 2003), or shifts in the international system of trade (Irwin and ORourke 2011)? But military power and its influences over global commerce remains under-explored, particularly for this very crucial period for the histories of world trade and military expansions. How did the rise of a few hegemonic powers, and the rapidly growing use of the tools necessary for the expansion of power and influence, affect trade?

Our study uses archival naval data to assess the impact of sea power projection by the major powers of the time on bilateral trade patterns from 1870 to the precipice of the Great War. Outright wars can disrupt trade through a variety of channels, through embargos, or privateering activities, or the fomenting of market uncertainty (Williamson 2011). Naval vessels, an important tool for international war-making, can conceivably either strengthen or hinder such forces. While the trade-stimulating peace of the *pax Britannica* prevailed during this time, naval powers still exerted great influence over trade patterns, both in positive and negative ways.

Rahman (2010) establishes a general link between naval power and trade for the 18th, 19th and early 20th centuries. Specifically, fighting war ships tended to lower world trade, even for neutral countries. On the other hand, neutral or allied ships tended to be a boon to world trade. The paper shows these naval effects to be both statistically significant and economically meaningful. However, the sea power-projection measures used are quite aggregative. For each naval power, the author counts the stock of capital fighting ships to construct annual time series of potential power projection for each global power. But these measures do not distinguish between active versus inactive or repairing vessels, nor do they capture the different kinds of ships deployed or the location of deployed ships. To estimate the trade impacts of active vessel deployment *to a specific region*, such distinctions are crucial.

This study provides a test of a particular aspect of the Kindleberger Hypothesis, which states that hegemonic powers produce public goods that can generate positive spillovers such as peace and commercial and financial security (Kindleberger 1973, 1981). Specifically, we analyze naval power projection, a critical tool to promote hegemonic influence, and its effects on world commerce. This approach allows us to capture *de facto* measures of power projection, as opposed to *de jure* changes in international policy by hegemons.

Following Rahman (2010), we focus on a much neglected player in the international infrastructure of commerce: sea powers. Here we exploit the unprecedented degree of detail concerning naval activities to establish more precisely the links between the activities of particular naval powers and global commerce. We construct power metrics using various naval vessels, which vary over naval power country, region and time. To these measures we link bilateral trade data (which vary by country-pair and year) and conflict data (which also vary by country-pair and year). We analyze not only how a naval power's ships stationed in a particular region can affect trade between two regions, but also differences between the effects of a naval power's own trade and the effects on other countries' trade. The distinction is important, as a navy's effects on commerce may be considered a private good for the naval power, but a (sometimes quite expensive!) public good for all others. That sea-power has been used as a national defense strategy to protect one's own trade and commercial interests remains fairly uncontroversial.[1] But the public good nature of sea-power can create a host of potential international externalities that may either help or harm the trade of other nations. Such a study sheds further light on the important factors influencing the great international wave of commerce of the latter 19th century.

This work joins the group of papers analyzing the effects of military power and trade. One branch of analysis considers the effects of international conflict on trade.[2] Another branch tackles the transport infrastructure of trade (Irwin and O'Rourke 2011), of which sea-going navies form an important component.

Of course, capturing the *causal* effects of naval power projection on trade is complicated by the fact that naval deployment is in part motivated by trade. Naval powers endeavor to

[1] See for example Lewis (1959), Crowhurst, (1977), Harding (1999).

[2] Results from this body of work are mixed. Bergeijk (1994), Mansfield and Bronson (1997) and Glick and Taylor (2010) estimate gravity models and find that conflict lowers trade; Mansfield and Pevehouse (2000) and Penubarti and Ward (2000) also estimate gravity models but find no statistically significant effects of conflict on trade.

protect their own trade, and often seek to disrupt the commerce of rival powers. To address endogeneity, we employ a two-stage strategy. First, we develop a model of naval power projection. A country deploys naval capital to different regions around the world for many motivations, including the fact that naval capital was deployed there by a rival power. Thus, we develop a simultaneous equations model, where naval deployment to a certain region at a certain time is jointly determined by all major naval powers. We identify the system using a number of country-specific variables that we argue are orthogonal both to the naval deployment of a rival power in a particular region, and to bilateral trade between any two particular regions. This "arms race" model produces estimated measures of naval power deployed around the world.

In the second stage, we incorporate these estimates in a gravity trade model. Following Glick and Rose (2002) we construct a gravity model with panel data using country-pair fixed effects estimation, so that we control for any time-invariant country-pair characteristics. The naval power estimates created in the first stage form our instruments to measure the spillover effects of power projection on commerce. Arguably they can influence trade between two particular countries but are themselves not influenced by such trade. Concentrating attention on the spillover effects of navies provides us another view of the causal effects of military expenditures by hegemonic powers on international trade.

We use this framework to help us answer a number of questions. How have naval powers influenced the ebb and flow of international commerce in history? More specifically, did the active use of naval force help spur trade and commerce for that naval power? Further, we can test the "naval corollary" to the Kindleberger Hypothesis - do we observe naval powers creating the kinds of public goods that fostered greater trade among third parties?

We first compile data on vessels, their stations and their characteristics from the navy registries of four naval powers: England, France, Germany, and the United States. These registry books, housed in the National Archives and arranged in annual volumes, maintain lists of active naval vessels, their present duty or station, and basic ship characteristics such as rate, number of guns, ship personnel, tonnage and displacement.

To this we merge a number of other data series. Bilateral trade data are assembled from two main sources: Barbieri (1996) and Mitchell (1992, 1993, 1998). The Barbieri (1996) dataset contains bilateral trade for around sixty countries during the period 1870 1947. Data here typically measure bilateral trade between countries a and b by summing imports into a from b and into b from a. We augment this with data from Mitchell (1992,1993,1998) to fill in some of the gaps in Barbieris coverage from 1870-1913.

Measures of wars are compiled using data on militarized interstate disputes collected by the Correlates of War Project (COW) at the University of Michigan. This dataset measures both the incidence and intensity of hostility at the country level. We code our war variable with conflicts of hostility at a fairly high level of intensity (these include blockades, occupations of territory, seizures, clashes, raids, declarations of war, uses of weaponry, and interstate wars).

Finally, a number of other standard variables are added to estimate the gravity model; these include real GDP, population, and various country-pair characteristics, such as contiguity and distance. Real GDP and per capita GDP data come predominantly from Maddison (1995,2001), supplemented where necessary by data from Mitchell (1992,1993,1998). The CIAs World Factbook is used to provide a number of country-specific variables, including longitude and latitude, land area, physically contiguous neighbors and common languages.[3]

The final merged dataset provides us with a method to gauge the global effects of military power that evolves both spatially and longitudinally. Each country-pair year observation includes measures of "naval power." These are aggregative measures of naval power active in waters through which commerce between two nations could conceivably flow. While studied and discussed extensively by naval historians, this rich data on naval vessel deployment has hitherto never been codified, and thus has never been used in cliometric studies.

Our results provide a number of insights. With our first stage, we see that the English and French competed primarily with each other. But whereas the English also reacted to and attempted to match German naval deployments when they began to ratchet up in the 1890s, the French seemed to have their sights strictly on English naval developments. Further, the U.S. tended to compete with Germany and France but to avoid the British.

Using our naval instruments generated from this exercise in the gravity model, we discover

[3]We use these time-invariant measures only with the pooled version of the gravity model, the results for which we do not report here.

that both the English and American navies were promoters of global commerce. The French Navy on the other hand promoted its own trade but tended to disrupt the trade of others. Our results are broadly consistent with the different naval strategies among the global powers (the *Bluewater School*, the *Jeune Ecole*, Mahanian doctrine, etc.), and demonstrate that whether the Kindleberger Hypothesis held during this time depended on the hegemon and its strategy vis-a-vis the world.

The rest of the paper is organized as follows. Section 2 provides some historical background. Section 3 explains the first stage arms race model, and section 4 explains results from the gravity model.

2 Background

2.1 The Projection of Sea Power...

In the second half of the nineteenth century tensions between states found a new expression through arms races. The mid-nineteenth century naval race between Britain and France was in fact the first example of an arms rivalry between modern societies. The race was particularly fierce in the latter 19th century, despite (or perhaps due to) the extended peace of the *Pax Britannica*. This effectively ended in 1912 when the exchange of the Grey-Cambon letters ushered a new era of naval cooperation between Britain and France (Williamson 1969). Before that point however an enormous global naval infrastructure had been erected. The England-France arms race had contributed more than any other factor to the emergence of the modern battleship, "the most complicated machine of the nineteenth century" (Hobson 2002), and the primary mode of naval power projection.

Many underlying factors motivated the surge in naval projection by Western nations. Among these were the 'myths of empire,' drawn from the racist, social Darwinist, and mercantilist philosophies prevalent at the time (Hobson 2002). The alleged necessity of expansion was fueled by the need to stem the rise of competing empires, to control markets and sources of raw materials, and to control 'inferior races' by running their affairs. Imperialism and navalism were jointly driven by these factors. The naval powers, although nominally at peace with each other, engaged in a 'silent war of steel and gold,' developing their naval programs and using all industrial and financial resources they could muster (Ropp 1987). Enthusiasm for potential future war spurred much of this naval buildup (Glaeser 2009).

This paper suggests that the naval arms race happened for many political and strategic reasons unrelated to commerce protection, shaping our empirical study in the next section. History demonstrates that naval buildups were often motivated through 'artificial means.' Often it did not depend on the protection of shipping; in fact some suggest all that mattered was the nation's economic strength relative to that of its rivals (Gough 1991). And with industrialization, naval power increasingly became an *offense* weapon by which hegemons could exert pressure on modern industrial nations (Kennedy 1991).

Throughout this period England led the race, keeping well ahead of its closest rivals by spending around £5M annually through the end of the 19th century.[4] Part of its goal was to persuade its primarily rival France that they could never win a naval competition with them. Not only did this not have the expected effect on France, it also helped spur the 1898 Navy Law, committing Germany to building a new navy to directly compete against the Royal Navy (Hobson 2002).

During this time British defense strategy was under the so-called *Bluewater School*, which emphasized dominant command of the sea. The necessary precondition of such superiority was to place its vessels near the ports of foreign regions. This was deemed the most cost-effective way for England to defend her hegemonic position. To accomplish this legislation such as the Naval Defense Act and the Spencer Program were initiated and effectively created a massive naval buildup.[5]

As for France, the end of the Franco-Prussian War in 1870 and the peace terms that followed stripped the nation of its territory and imposed a huge indemnity on the country. This helped create a desire among the French for revenge, and this arguably spurred a more muscular military

[4] Source: http://www.cityofart.net/bship/gunnery.html

[5] The Naval Defense Act established the standard for England to maintain its number of battleships to be at least as many as those from the next two largest navies (which at that point were France and Russia). This greatly contributed to the arms race, though of course the original objective was to prevent the race in the first place. The Spencer Program was another expansion aimed to match foreign naval growth.

stance (Hobson 2012). There was a great contingent of the French populace that was eager for imperialism. They strongly emphasized the importance of continued colonialism for the further development of France as a great power. Above all they were obsessed with developing an effective strategy against Britain, in continuing the global struggle for colonial territories and markets.

But at the birth of the Third Republic, French naval strategists grappled with the question of what kind of new navy they should build. What could their navy achieve, given Britain's clear domination of the seas and the limited means at hand? The French Admiral Baron Grivel suggested through methodical study that a maritime power of secondary stature should engage in commerce warfare against stronger opponents and traditional squadron warfare against weaker ones. The implication was that France's naval strategy would be quite distinctive from England's.

What about other naval powers? The navies of England and France had vital roles to play in promoting national defense, and they relied on centuries of experience with naval warfare to help them draw lessons for the latter-19th century context. By contrast, the United States and Germany had much younger navies, with more marginal roles for national defense and less history and experience on which to rely (Hobson 2002). The United States in particular was not regarded as a serious challenger to England during most of this period (Sprout and Sprout 1943).

Yet while the U.S. had a much smaller fleet, its strategy slowly evolved into one similar to that of England's. Starting modestly in the 1870s, the U.S. began its naval buildup in earnest in 1883, and by 1890 the modernization program greatly accelerated. At the initiation of the program the U.S. Navy ranked 12th among the powers; by 1900 it had advanced to third place (McBride 2000).

Much of this expansion can be attributed to Alfred Mahan, whose naval doctrine some might call a "theory of mercantilistic imperialism" (Hobson 2002). The naval expansion he championed was tightly linked to his unwavering support for overseas territorial and economic expansion. It was Mahan who introduced to the U.S. the idea of naval use during peacetime to generate economic benefits from command of the sea, an idea long championed in England.

Germany also began to expand naval power, starting in the 1890s. Kaiser William envisioned a grand internationalist and expanding future for Germany. To the dismay of the English, the kaiser's policy called for a navy equal to that of England's. Soon thereafter the British and the Germans began "programs of vilification," suggesting existential threats from the other power and fueling the naval arms race (Glaeser 2009).

2.2 ...And Its Effects on Commerce

This paper suggests that the arms race described in the last section had important effects on inter-continental trade, both in positive and negative ways. The flexing of military might by hegemons involved economic costs and benefits, both for the hegemons and for the world. The net effects of such exploits in history should be more fully explored (Findlay and O'Rourke 2008).

That navies can provide a public good such as commerce security has been suggested before (Irwin and O'Rourke 2011). Particularly during the latter 19th century trade was often diverted for security reasons, motivated mainly by the naval power that had primary control over the shipping lanes (Taylor 2003). The Royal Navy in particular had strong interests in securing the oceans and sea lanes for trade, given that England was becoming a large net importer of food (Irwin and O'Rourke 2011). And dramatic trade liberalization starting in the 1840s also made England increasingly dependent on cotton. England's leading naval strategist in 1877 summed it up nicely: "In 1813, the British people lived on the produce of their soil. In 1875, that people required side by side with every pound's worth of raw cotton for manufacture, one pound's worth of raw corn or flour for their sustenance" (Colomb 1877).

Naval leadership in England recognized the rising importance of international commerce and the need to protect it. Captain J.R. Colomb of the Royal Marines lay the foundations of the *Bluewater School* in 1867 by ranking England's naval priorities as, first, to defend Great Britain and Ireland, next, to protect English commerce, and third, to occupy India. Concerning the second point, he stated that "It is beyond dispute that the general welfare of the Empire depends chiefly upon its commercial prosperity, and therefore we conceive that our regular forces abroad should be distributed in time of peace in such a manner as would best secure protection to our commerce in the event of sudden war" (Colomb 1867). He envisioned the navy affording protection not merely to the English Channel (although that of course was a prime necessity) but also to the main trading routes around the world, those that stretched across the Mediterranean, to India and China, to the West Indies, and the Pacific.

Such a philosophy held that lasting peace through naval influence could promote prosperity and trade performance (Mitchener and Weidenmier 2005). In order to protect trading routes, English ships were spread far and wide. This form of "global leadership" served as a stabilizing force up to 1913 (Kindleberger 1973). Very often merchants requested and sought after the protection of British convoy, spurred in part by prohibitive maritime insurance rates.

Once the U.S. shed its postbellum isolationism, its navy too became an instrument for the facilitation of commerce. Though not as dependent on foreign trade as England, the U.S.'s regional hegemony was sensitive to global finance (Mitchener and Weidenmier 2005). The U.S. often used its naval powers for commercial missions, starting perhaps most famously when it sent one-fourth of its Navy in 1853 to open Japan to American traders (Morck and Nakamura 2007). The U.S. intervention in Santo Domingo made credible the threat of naval forces conducting gunboat diplomacy or seizing foreign customs houses in Central and Latin America to promote trade (Mitchener and Weidenmier 2005). And when American naval forces were sent to the Philippines to wage war in 1898, Philippine merchants urged the U.S. to take control of the Philippines in the belief that this would bolster their business (Rockoff 2012).

Yet history is rich with illustrations of commerce *disruption* by naval powers during the 19th century, most dramatically during times of war. During the early 19th century both British and French navies regularly seized American cargo and ships (Irwin 2005). As industrialization became increasingly fueled by international commerce, sea power rose in importance for economic and industrial strategy. Naval strategists recognized that countries like England and Germany had become perilously dependent on imports of foodstuffs from overseas (Offer 1989).

Maritime commerce was thus vulnerable to aggressive navies, and in this area France led the way. The Declaration of Paris which ended the Crimean War also ended France's right to authorize privateers to prey on enemy commerce; of course this meant that the French navy itself was free to carry on a legal war against commerce. The primary objective of the *Jeune Ecole* was in fact to use French naval power to economically disrupt its rivals, in part by raising insurance rates that would subsequently lead to higher prices for food and raw materials (Hobson 2002).

The *Jeune Ecole* was the tacit recognition that France could not compete with England one for one in ship building and deployment (as we will empirically see in the next section). Rather its navy would focus on England's (and other rival powers') apparent vulnerability of international commerce dependence. A total command of the sea was not required for commerce warfare, and the opportunities for such warfare expanded rapidly as trade grew (Ropp 1971). Of course this type of commerce-raiding can impose heavy costs, not just in the form of lost or captured merchandise - trade can be diverted through less expeditious or efficient routes. And merchants and sailors demanded higher compensation for *ex ante* threats to their voyages (Hilt 2006).

Thus whether naval power helped or hurt maritime commerce appears to be an open and empirical question. Anderson (2006) suggests that a country's commercial policy regarding trade depends crucially on the strengths of its enforcement. Whether or not a hegemon uses its navy to promote trade is a calculus based on *ex ante* gains and losses. We empirically explore the effects of naval power on commerce in the next sections.

3 Estimating Measures of Naval Power Projection - An "Arms-Race" Model

From the history of 19th century naval power, we see that naval expansion by hegemons likely had profound trade impacts. But testing the actual impact of naval deployment is complicated since it was itself motivated, at least in part, by concerns over commerce. We tackle the problem in two stages.

For the first stage, we develop a naval arms-race model by estimating a simutaneous equations model (SEM). Consider the following system of equations that estimate naval power projection for three powers: England, France and the United States:

$$navy_{uk,s,t} = \beta_0 + \beta_1 navy_{fr,s,t} + \beta_2 navy_{us,s,t} + \sum_{k=3}^{N} \beta_k x_{uk,k,s,t} + \varepsilon_{s,t} \tag{1}$$

$$navy_{fr,s,t} = \gamma_0 + \gamma_1 navy_{uk,s,t} + \gamma_2 navy_{us,s,t} + \sum_{k=3}^{N} \gamma_k x_{fr,k,s,t} + \upsilon_{s,t} \tag{2}$$

$$navy_{us,s,t} = \delta_0 + \delta_1 navy_{uk,s,t} + \delta_2 navy_{fr,s,t} + \sum_{k=3}^{N} \delta_k x_{fr,k,s,t} + \epsilon_{s,t} \quad (3)$$

Here *navy* constitutes some measure of naval power projection in station s in year t by England, France or the United States. These are assumed to be jointly determined.[6] The x's on the other hand are assumed to be exogenous determinants of power projection by one naval power.[7] The x's thus conceivably allow us to estimate the effect of one navy's projection on another's. $\varepsilon_{s,t}$, $\upsilon_{s,t}$ and $\epsilon_{s,t}$ are the structural errors.

By "naval projection," we mean the extent to which navies deploy forces to specific regions. Because we have data on the ships stationed abroad for each naval power, we are able to construct such projection metrics. We will use alternative measures of the number of vessels deployed in a region, the total tonnage of these deployed vessels, and the total officer personnel assigned to these deployed vessels.

These first-stage exercises accomplish a number of things. It provides a new quantitative assessment of the first "arms-race" among hegemonic powers in modern history. It allows us, in an empirically robust way, to observe who "competed" against whom. More critically to the overall objective of the paper, it produces instruments for naval power projections that we use in the next section to assess the *causal* effects of such projections on world trade.

We use original-source data for four naval powers. These include the number of ships deployed, tonnage, and personnel aboard each vessel for England (1878-1914), France (1875-1913), U.S. (1870-1911), and Germany (1890-1910).[8] Table 1 provides some summary figures for these data. For power projection measures, we alternatively use total number of vessels, total ship tonnage (displacement), and total number of officer personnel aboard vessels. We do not use total number of guns on ships, or the horsepower of ships, because these measures are not available for all naval powers considered, and because the degree of comparability across naval powers may be

[6] Germany is not included in the main system of equations due to data limitations, although we do include Germany for one set of results for illustrative purposes.

[7] These are indexed from 3 to N simply because the first two variables in each regression is the rival naval power's measured projection.

[8] The gaps in coverage are for full years (certain annual volumes of navy registries were unavailable). For years that are covered, the data coverage is comprehensive and complete - we capture every active vessel, where it is deployed, and basic ship characteristics.

questioned.

Observations are at the region(station)-year level (s, t). Regions are the North Atlantic, South Atlantic, North Pacific, South Pacific, North Sea (Europe), the Mediterranean, the Asiatic front, and the Indian Ocean. In these specifications the home station is also included (we can include specifications excluding home station; results are quite similar to those presented here).

Tables 2-7 summary our findings. The first three variables listed are considered "exogenous" (x's) and influence the number of ships and gross tonnage of deployed vessels (these are *observed shifters* of naval power). Naval expenditures (measured in millions on 1913 pounds) vary only by year, and are aggregative (involve funding for all naval activities, including paying personnel, building and repairing vessels, research and development, etc. Spending is likely unrelated to foreign navy's deployment to a particular region). Distance varies only by station (measured as nautical miles between home and the center of the region). The expenditure-distance cross term obviously varies across both time and region.

Consider the first specification in each table. Whether measured as number of ships or total tonnage of these ships, expenditures and distance positively influence deployment, while the cross-term negatively influences deployment. This is generally true for all navies (although for the U.S. case it appears that there is no great appetite for sending ships to distant waters - this is likely because during much of this period, the U.S. maintained a far more provincial navy). In general the further one is from their home, the greater is naval power projection. This likely stems from the wish to flex naval power abroad, protect far-flung interests, and the need for a critical mass of vessels to sustain more distant excursions. The negative result for the cross-term suggests that naval buildup from current expenditures start at home. Naval money turned into vessels are first deployed in local waters, and over time are sent out to distant seas.

In each table the first two specifications show simple OLS estimates, while the last three come from the simultaneous equation model. The second specification includes the power projection of another navy, and this obviously suffers from simultaneity bias. So looking at *French navy deployment*, for example, we simultaneously estimate English and French deployment, using English and French naval expenditures, distances, and expenditure-distance cross terms as exogenous variables (shifters). The estimates in tables 2 and 3 are the measured effects of French deployment on English deployment (the corresponding effects of English deployment on French deployment are reported in tables 4 and 5).

It seems fairly clear (from table 2) that for every vessel the French put out, the English navy responds nearly in kind. It tends to avoid the United States, on the other hand. Note that when we include Germany in the final specification, we only look at the 1890s and 1900s. There is a strong association between English and German deployment, which makes sense. England began to bring its ships back closer to home to deal with the German threat. In terms of total tonnage deployed, England tends to overwhelm France. It responds one-and-a-half to three times as strongly. On the other hand, it appears totally indifferent to the U.S.

For the French (tables 4 and 5), we first see that once again naval expenditures and distance are both positive predictors of power projection, while the cross-term is negative. But when we include measures of English power projection, these variables fall to insignificance. England really drives the French. But they can't match the English - they send about a half to two-thirds of the number of vessels that England does, and a quarter to a half of the gross ship tonnage that England does. Another difference is that France appears to "compete" with the United States, at least in terms of numbers of vessels deployed. Finally note that while the English closely match the Germans, the French tend to avoid them.

Tables 6 and 7 demonstrate factors affecting U.S. naval power projection. The standard variables that motivate English and French navies do not seem to work in U.S. case, at least for number of vessels. Rather, the U.S. reacts to the other naval powers a lot. Looking at the SEM specifications, it tends to match French and Germany, both in terms of the number of ships and gross tonnage, but it tends to avoid the English altogether.

Finally, we also perform the same empirical exercises, but use total number of line officers assigned to vessels, and the total number of line and engineer officers assigned to vessels, as alternative measures of naval power projection. Similar results emerge (results not reported). We use these as alternative predicted measures of power projection in the next section.[9]

[9] Alternatively we estimate all these using random effects - results remain consistent in signs and magnitudes.

4 Effects of Naval Power Projection on Bilateral Trade

We now want to see how the naval arms-race among the super-powers of the late 19th century affected global commerce. To that end we use the estimates from our previous exercise in a panel gravity model (for what follows, we use the fourth specification from tables 2-7). That is, we use predicted measures of naval projection (alternatively using number of vessels, gross vessel tonnage, total number of line officers, and total number of line and staff officers) as separate explanatory variables in our gravity model. We thus consider these measures as potential *spillover* effects from naval build-up on commerce.

Measures of naval power projection are given by the following dot product:

$$power_{ijkt} = \widehat{navy}'_{kt} \cdot s_{ij} \tag{4}$$

where $\widehat{navy}_{kt}$ is a 1-by-N vector of naval power projection measures for naval power k at time t across N different regions, and s_{ij} is a 1-by-N *spatial* vector, comprised of ones and zeros denoting the relevant regions through which conceivably maritime trade between countries i and j would pass.[10] In producing our power measures, we use *predicted* values of $navy_{kt}$ that we produce from the above exercises - specifically we use estimated values of equations (1) - (3), which simultaneously estimate power projection by England, France and the United States.

We have two alternative series of these spatial vectors (s's). The first considers any region through which trade between countries i and j would pass as fair game (takes on a value of 1). The second considers only the regions where i and j are located - it thus ignores in-between regions, and so considers two regions at most. Results below are only for the first case, but results for the second echo these quite closely (not reported but available upon request).

We use four alternative estimates of naval power projection, for each estimate captures somewhat different aspects of power. For example, the number of vessels deployed in a region may capture the potential dispersion of power over a wide range, but fails to measure the intensity of this power. Tonnage and ship personnel measures better capture the degree and force of naval power deployed but may fail to capture the ability to spread its influence.

[10] Once again, there are nine possibilities - the home station, the North and South Atlantic, the North and South Pacific, the North Sea, the Mediterranean, the Asiatic front, and the Indian Ocean.

All gravity model estimates use bilateral-pair fixed effects and year effects. Results from these exercises are displayed in tables 8-14. Table 8 considers the effects of the English navy on English trade. Results are negligible, although coefficients on various measures of English sea power are all positive.

In table 9 we look at the effects of the English navy on the trade of other countries (those that do not involve England). Here there appear to be positive spillovers. This makes sense, England being the dominant force in the world, essentially serving as the global police. The magnitudes of these effects are modest. For example, a one percent increase in naval personnel aboard these deployed vessels generate a 0.05 percent increase in trade volumes. But it bears repeating that these are spillover effects, the unintended consequences of the naval arms race. Thus it appears that Kindleberger's notion of the stability of hegemonic influence does have some validity when we consider the Royal Navy.

In tables 10 and 11 we turn our attention to France. In table 10 we consider the effects of the French navy on French trade. It appears French naval power positively influences its own commerce. This would be consistent with the historical record, as France was bent on protecting its commercial interests. In table 11 we consider the effects of the French navy on the trade of other countries (those that do not involve France). Here the French navy appears to be a destroyer of commerce. As we mentioned earlier, this is consistent with a *Jeune Ecole* strategy of commerce raiding. It thus appears that its navy, in protecting its own commercial interests, did so at the expense of the commerce of the world.

Tables 12 and 13 demonstrate the effects of U.S. naval power on commerce. The U.S. appears to help both its own trade and produce positive spillovers. This would be consistent both with a Mahanian strategy and Kindleberger's notion of America's rising hegemonic influence around the world.

Finally, table 14 runs the rat race between France and England, looking at trade that involves neither France nor England. With the exception of using number of vessels as a power measure, we see that our results from tables 8-11 hold firm; England bolsters trade, and France destroys it (and number of vessels is admittedly a weak measure of true power projection). In specifications 5 to 7 we also include measures for the U.S. Coefficients on these variables are statistically insignificant, but informatively, the signs for coefficients for English and French power remain as before.

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A Tables

Table 1: Summary of Naval Statistics

	Naval Power			
	England	France	United States	Germany
coverage	1878 - 1914 (with gaps)	1872 - 1913 (with gaps)	1870 - 1912	1890 - 1910 (with gaps)
total vessels (includes inactive vessels)	552	724	464	238
average displacement per ship (tons)	3657.1	3191.0	3206.6	5129.7
average no. of officers per ship	3.1	5.2	1.2	14.4
average no. of engineers per ship	1.5	1.4	0.3	3.2
average no. of guns per ship	6.9	6.0	-	-
average horsepower per ship	12635	4860	-	7683

Table 2: Estimating Number of English Vessels Deployed

Variable	(1)	(2)	(3)	(4)	(5)
	all stations				
	OLS	OLS	SEM	SEM	SEM
expenditures	0.38***	0.27***	0.76***	0.17***	0.022
	(0.13)	(0.08)	(0.15)	(0.066)	(0.05)
distance	0.001***	0.0006***	0.003***	0.0002	0.0008***
	(0.0003)	(0.0002)	(0.0007)	(0.0002)	(0.0003)
exp*distance	-0.00005***	-0.00002***	-0.00012***	-0.00006	-0.00002
	(0.00001)	(0.000007)	(0.00003)	(0.00007)	(0.00005)
French navy deployment	-	0.63***	-1.88***	0.84***	0.98***
		(0.11)	(0.44)	(0.18)	(0.20)
U.S. navy deployment	-	-	-	-0.82***	-0.34**
				(0.10)	(0.15)
German navy deployment	-	-	-	-	1.45***
					(0.23)
R-squared	0.09	0.49	-	-	-
Chi-squared	-	-	27.8***	147.5***	95.8***
Observations	315	243	243	225	117

Notes: Dependent variable is logged number of English vessels deployed in a region
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 3: Estimating Aggregative Tonnage of English Vessels Deployed

	all stations				
Variable	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	SEM	SEM	SEM
expenditures	5215.1***	2477.0***	3642.5*	-151.7	131.8
	(1273.3)	(523.5)	(2021.6)	(185.6)	(334.3)
distance	5.04**	2.08*	3.27	1.44	0.99
	(2.55)	(1.20)	(2.86)	(1.04)	(1.37)
exp*distance	-0.44***	-0.16***	-0.28	0.023	-0.004
	(0.13)	(0.05)	(0.22)	(0.02)	(0.03)
French navy deployment	-	1.61***	0.96	3.29***	1.69***
		(0.19)	(1.08)	(0.30)	(0.27)
U.S. navy deployment	-	-	-	0.08	0.10
				(0.22)	(0.17)
German navy deployment	-	-	-	-	0.97***
					(0.20)
R-squared	0.28	0.78	-	-	-
Chi-squared	-	-	229.9***	190.2***	213.1***
Observations	315	252	252	234	117

Notes: Dependent variable is logged tonnage of English vessels deployed in a region
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 4: Estimating Number of French Vessels Deployed

Variable	(1) OLS	(2) OLS	(3) SEM	(4) SEM	(5) SEM
	all stations				
expenditures	0.67*	-0.08	-0.21	-0.09	-0.007
	(0.38)	(0.19)	(0.38)	(0.31)	(0.14)
distance	0.0013***	0.0003	0.00002	0.0005	-0.0006*
	(0.0005)	(0.0004)	(0.00002)	(0.0005)	(0.00032)
exp*distance	-0.0001***	-0.00003	-0.00007	-0.00005	-0.000003
	(0.00004)	(0.00003)	(0.00005)	(0.00004)	(0.000003)
English navy deployment	-	0.69***	0.52*	0.62***	0.66***
		(0.07)	(0.32)	(0.19)	(0.14)
U.S. navy deployment	-	-	-	0.57***	0.11
				(0.14)	(0.15)
German navy deployment	-	-	-	-	-0.71**
					(0.33)
R-squared	0.05	0.46	-	-	-
Chi-squared	-	-	9.2*	26.5***	49.8***
Observations	279	243	243	225	117

Notes: Dependent variable is logged number of French vessels deployed in a region
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 5: Estimating Aggregative Tonnage of French Vessels Deployed

Variable	*all stations* (1) OLS	(2) OLS	(3) SEM	(4) SEM	(5) SEM
expenditures	5056.8***	-868.7	1859.3	49.7	-83.0
	(1979.5)	(733.8)	(1537.4)	(181.8)	(542.2)
distance	3.66*	0.10	2.05	-0.46	-0.82
	(2.20)	(1.07)	(1.82)	(0.41)	(1.21)
exp*distance	-0.55***	-0.015	-0.27*	-0.013	0.004
	(0.22)	(0.08)	(0.15)	(0.02)	(0.08)
English navy deployment	-	0.42***	0.24***	0.31***	0.46***
		(0.03)	(0.09)	(0.03)	(0.08)
U.S. navy deployment	-	-	-	-0.009	-0.15*
				(0.07)	(0.08)
German navy deployment					-0.27*
					(0.16)
R-squared	0.16	0.74	-	-	-
Chi-squared	-	-	11.6***	187.6***	112.1***
Observations	288	252	252	234	117

Notes: Dependent variable is logged tonnage of French vessels deployed in a region
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 6: Estimating Number of U.S. Vessels Deployed

Variable	*all stations* (1) OLS	(2) OLS	(3) SEM	(4) SEM
expenditures	0.10	0.06	0.03	-0.21
	(0.08)	(0.11)	(0.18)	(0.33)
distance	-0.0002*	-0.0004***	-0.0003	-0.00003
	(0.0001)	(0.00015)	(0.0005)	(0.0009)
exp*distance	0.000005	0.00002	0.00004	0.00004
	(0.00001)	(0.00002)	(0.00004)	(0.00007)
English navy deployment	-	0.089	-1.01***	-0.41
		(0.08)	(0.27)	(0.51)
French navy deployment	-	0.12**	1.11***	-0.84
		(0.05)	(0.27)	(0.58)
German navy deployment	-	-	-	2.36***
				(0.82)
R-squared	0.03	0.10	-	-
Chi-squared	-	-	131.1***	14.9**
Observations	378	225	225	117

Notes: Dependent variable is logged number of U.S. vessels deployed in a region
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 7: Estimating Aggregative Tonnage of U.S. Vessels Deployed

Variable	*all stations* (1) OLS	(2) OLS	(3) SEM	(4) SEM
expenditures	2076.2***	1297.6*	9837.6***	-1020.3
	(772.1)	(762.4)	(3908.1)	(3713.9)
distance	0.21	0.42	4.17	1.17
	(0.65)	(0.98)	(3.24)	(6.05)
exp*distance	-0.14	-0.04	-1.03**	0.56
	(0.11)	(0.12)	(0.47)	(0.81)
English navy deployment	-	0.27**	-2.02**	-1.93*
		(0.13)	(0.98)	(1.2)
French navy deployment	-	-0.49**	4.14*	1.27
		(0.22)	(2.18)	(1.91)
German navy deployment	-	-	-	3.99**
				(1.93)
R-squared	0.10	0.18	-	-
Chi-squared	-	-	8.52*	19.75***
Observations	378	234	234	117

Notes: Dependent variable is logged tonnage of U.S. vessels deployed in a region
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 8: Effects of English Naval Deployment (instrumented) on English Trade

Variable	(1)	(2)	(3)	(4)
$\ln(Y_iY_j)$	0.61***	0.62***	0.63***	0.62***
	(0.10)	(0.10)	(0.10)	(0.10)
$\ln(y_iy_j)$	0.19	0.19	0.19	0.19
	(0.17)	(0.17)	(0.17)	(0.17)
War	-0.25***	-0.25***	-0.25***	-0.25***
	(0.09)	(0.09)	(0.09)	(0.09)
Global War	0.10	0.10	0.10	0.10
	(0.076)	(0.08)	(0.08)	(0.08)
ln(No. of English vessels)	0.009	-	-	-
	(0.04)			
ln(Gross tonnage of English vessels)	-	0.004	-	-
		(0.004)		
ln(English naval line-officers)	-	-	0.01	-
			(0.008)	
ln(All English naval officers)	-	-	-	0.007
				(0.008)
R-squared	0.45	0.45	0.45	0.45
Observations	995	995	995	995
Number of country-pairs	40	40	40	40

Notes: Dependent variable is logged bilateral trade between England and another country.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 9: Effects of English Naval Deployment (instrumented) on Third-Party Trade

Variable	(1)	(2)	(3)	(4)
$\ln(Y_iY_j)$	0.42***	0.50***	0.54***	0.54***
	(0.08)	(0.09)	(0.09)	(0.09)
$\ln(y_iy_j)$	0.03	-0.08	-0.11	-0.12
	(0.15)	(0.15)	(0.15)	(0.15)
War	-0.001	0.003	0.007	0.01
	(0.12)	(0.12)	(0.12)	(0.12)
Global War	0.01	0.006	0.006	0.006
	(0.04)	(0.04)	(0.04)	(0.04)
ln(No. of English vessels)	-0.03	-	-	-
	(0.03)			
ln(Gross tonnage of English vessels)	-	0.018***	-	-
		(0.003)		
ln(English naval line-officers)	-	-	0.04***	-
			(0.007)	
ln(All English naval officers)	-	-		0.05***
				(0.008)
R-squared	0.21	0.19	0.18	0.18
Observations	3755	3755	3755	3755
Number of country-pairs	220	220	220	220

Notes: Dependent variable is logged bilateral trade between two non-U.K countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 10: Effects of French Naval Deployment (instrumented) on French Trade

Variable	(1)	(2)	(3)	(4)
$\ln(Y_iY_j)$	0.22	0.21	0.23	0.21
	(0.16)	(0.16)	(0.16)	(0.16)
$\ln(y_iy_j)$	0.34	0.33	0.33	0.33
	(0.28)	(0.28)	(0.28)	(0.28)
War	0.04	0.03	0.04	0.03
	(0.12)	(0.12)	(0.12)	(0.12)
Global War	-0.06	-0.07	-0.07	-0.06
	(0.08)	(0.08)	(0.08)	(0.08)
ln(No. of French vessels)	0.09*	-	-	-
	(0.05)			
ln(Gross tonnage of French vessels)	-	0.16***	-	-
		(0.06)		
ln(French naval line-officers)	-	-	0.11*	-
			(0.06)	
ln(All French naval officers)	-	-	-	0.12***
				(0.04)
R-squared	0.53	0.52	0.53	0.53
Observations	698	698	698	698
Number of country-pairs	27	27	27	27

Notes: Dependent variable is logged bilateral trade between France and another country.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 11: Effects of French Naval Deployment (instrumented) on Third-Party Trade

Variable	(1)	(2)	(3)	(4)
$\ln(Y_iY_j)$	-0.08	-0.08	-0.08	-0.07
	(0.08)	(0.08)	(0.08)	(0.08)
$\ln(y_iy_j)$	1.02***	0.98***	0.99***	0.98***
	(0.14)	(0.14)	(0.14)	(0.14)
War	-0.01	-0.01	-0.02	-0.02
	(0.08)	(0.08)	(0.08)	(0.08)
Global War	-0.07***	-0.06**	-0.07**	-0.07**
	(0.03)	(0.03)	(0.03)	(0.03)
ln(No. of French vessels)	-0.17***	-	-	-
	(0.02)			
ln(Gross tonnage of French vessels)	-	-0.10***	-	-
		(0.03)		
ln(French naval line-officers)	-	-	-0.21***	-
			(0.03)	
ln(All French naval officers)	-	-		-0.15***
				(0.03)
R-squared	0.11	0.10	0.10	0.11
Observations	4982	4982	4982	4982
Number of country-pairs	237	237	237	237

Notes: Dependent variable is logged bilateral trade between two non-France countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 12: Effects of U.S. Naval Deployment (instrumented) on U.S. Trade

Variable	(1)	(2)	(3)	(4)
$\ln(Y_i Y_j)$	-0.19	0.013	-0.06	-0.07
	(0.21)	(0.20)	(0.20)	(0.20)
$\ln(y_i y_j)$	1.59***	1.30***	1.39***	1.40***
	(0.36)	(0.35)	(0.35)	(0.34)
War	-0.03	-0.03	-0.04	-0.03
	(0.13)	(0.13)	(0.13)	(0.13)
Global War	0.03	0.05	0.04	0.05
	(0.11)	(0.10)	(0.10)	(0.10)
ln(No. of U.S. vessels)	-0.03	-	-	-
	(0.03)			
ln(Gross tonnage of U.S. vessels)	-	0.012***	-	-
		(0.004))		
ln(U.S. naval line-officers)	-	-	0.036***	-
			(0.012)	
ln(All U.S. naval officers)	-	-	-	0.047***
				(0.013)
R-squared	0.03	0.13	0.09	0.08
Observations	540	573	573	573
Number of country-pairs	40	41	41	41

Notes: Dependent variable is logged bilateral trade between two non-U.S. countires.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 13: Effects of U.S. Naval Deployment (instrumented) on Third-Party Trade

Variable	(1)	(2)	(3)	(4)
$\ln(Y_iY_j)$	0.60***	0.56***	0.59***	0.58***
	(0.10)	(0.10)	(0.10)	(0.10)
$\ln(y_iy_j)$	-0.14	-0.13	-0.15	-0.13
	(0.16)	(0.16)	(0.15)	(0.15)
War	-0.10	-0.10	-0.11	-0.11
	(0.12)	(0.12)	(0.12)	(0.12)
Global War	0.03	0.02	0.02	0.02
	(0.04)	(0.04)	(0.04)	(0.04)
ln(No. of U.S. vessels)	0.074***	-	-	-
	(0.017)			
ln(Gross tonnage of U.S. vessels)	-	0.003	-	-
		(0.002))		
ln(U.S. naval line-officers)	-	-	0.03***	-
			(0.008))	
ln(All U.S. naval officers)	-	-	-	0.026***
				(0.008)
R-squared	0.17	0.17	0.17	0.18
Observations	2944	3075	3075	3075
Number of country-pairs	279	280	280	280

Notes: Dependent variable is logged bilateral trade between two non-U.S. countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses
with *10%, **5% and ***1%

Table 14: Effects of English and French Naval Deployment (instrumented) on Third-Party Trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\ln(Y_i Y_j)$	-0.30**	-0.17	-0.14	-0.13	0.12	0.19	0.26
	(0.12)	(0.12)	(0.12)	(0.12)	(0.18)	(0.18)	(0.19)
$\ln(y_i y_j)$	1.13***	0.92***	0.90***	0.89***	0.31	0.29	0.19
	(0.19)	(0.19)	(0.19)	(0.19)	(0.26)	(0.26)	(0.26)
War	-0.05	-0.03	-0.03	-0.02	0.005	0.01	0.005
	(0.13)	(0.13)	(0.13)	(0.13)	(0.20)	(0.20)	(0.20)
Global War	-0.002	-0.0003	-0.002	-0.002	0.05	0.04	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
ln(No. of English vessels)	-0.07**	-	-	-	-	-	-
	(0.03)						
ln(No. of French vessels)	-0.18***	-	-	-	-	-	-
	(0.03)						
ln(Gross tonnage of English vessels)	-	0.014***	-	-	0.008	-	-
		(0.004)			(0.008)		
ln(Gross tonnage of French vessels)	-	-0.25***	-	-	-0.13*	-	-
		(0.05)			(0.07)		
ln(English naval line-officers)	-	-	0.03***	-	-	0.027*	-
			(0.008)			(0.016)	
ln(French naval line-officers)	-	-	-0.37***	-	-	-0.36***	-
			(0.05)			(0.099)	
ln(All English naval officers)	-	-	-	0.033***	-	-	0.046***
				(0.01)			(0.01)
ln(All French naval officers)	-	-	-	-0.25***	-	-	-0.26***
				(0.04)			(0.07)
ln(Gross tonnage of U.S. vessels)	-	-	-	-	-0.005	-	-
					(0.004)		
ln(U.S. naval line-officers)	-	-	-	-	-	-0.016	-
						(0.013)	
ln(All U.S. naval officers)	-	-	-	-	-	-	-0.014
							(0.013)
R-squared	0.01	0.03	0.04	0.04	0.09	0.12	0.12
Observations	2851	2851	2851	2851	1660	1660	1660
Number of country-pairs	194	194	194	194	147	147	147

Notes: Dependent variable is logged bilateral trade between two countries.
Y_i denotes the GDP of country i; y_i denotes the GDP per capita of country i.
Inclusion of a naval power as independent variable implies that trade of that power is not included in observations.
All specifications include bi-lateral country and time fixed effects.
Standard errors clustered by country reported in parentheses with *10%, **5% and ***1%