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ROUTES INTO NETWORKS
THE STRUCTURE OF ENGLISH TRADE IN THE EAST INDIES, 1601-1833

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Routes into Networks

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Abstract

Drawing on a remarkable dataset compiled from ships' logs, journals, factory correspondence, ledgers, and reports that provide unusually precise information on each of the 4,572 voyages taken by English traders of the East India Company (hereafter EIC), we describe the EIC trade network over time, from 1601 to 1833. From structural images of voyages organized by shipping seasons, we map the (over time and space) emergence of dense, fully integrated, global trade networks: of globalization before globalization. We show that the integration of the world trade system under the aegis of the EIC was the unintended by-product of systematic individual malfeasance (private trading) on the part of ship captains seeking profit from internal Eastern trade.

Keywords: principal-agent problem, networks, global trade, historical sociology, the EIC.

Introduction:

In the first few years of the seventeenth century, a few intrepid sailors on small English ships crossed the Atlantic and Indian Oceans, haphazardly initiating trade wherever they found willing partners. Within one hundred and fifty years, thousands of sailors on hundreds of English ships laden with bullion, silver, and manufactured goods from the West set out for distant ports in the East Indies to collect commodities brought to the coast and readied for exchange by English factors resident in the East. Yet rather than return to England as directed, many captains cycled throughout the East, purchasing and exchanging goods manufactured in one locale for those of another, thereby profiting from uneven terms of exchange. These private traders, free-riding on company resources, engaged in an illegitimate and formally censured entrepreneurial activity in pursuit of their own interests. As a byproduct of this activity, these private traders laid the foundation for an integrated global market,[1] transforming the nature of East-West trade in a short period from a simple dyadic structure to vastly more complex multilateral networks of exchange, ultimately leading to the emergence of densely connected global markets.

This article considers the mechanisms behind this radical transformation. Drawing on a remarkable dataset compiled from ships' logs, journals, factory correspondence, ledgers, and reports that provide unusually precise information on each of the 4,572 voyages taken by English traders of the East India Company (hereafter EIC), we describe the EIC trade network over time, from 1601 to 1833. Specifically, we induce a graphical representation of the complete set of port-to-port linkages (26,000+ arcs) for *all* 4,572 voyages undertaken by the Company in order to represent the structure of the English-East Indies trading network for the 233 years spanning the Company's existence. From structural images of voyages organized by shipping seasons, we map the (over time and space) emergence of dense, fully integrated, global trade networks: of globalization before globalization. To anticipate the main argument, we show that the integration

[1] The phrase "international trade" is anachronistic. By global we simply mean something less cumbersome than inter-societal, if not world-wide. We refer to the structure of the EIC trade as *global trade* as a short-hand expression for large-scale long-distance integrated trade systems.

of the world trade system under the aegis of the EIC -- what we will refer to as the structure for globalization -- was the unintended by-product of systematic individual malfeasance (private trading) on the part of ship captains seeking profit from internal Eastern trade.

The EIC has been the focus of considerable scholarly attention as a consequence of its critical role in first seeding and then securing the expansion of the British Empire in the East (Dodwll 1920; Roberts 1938). Likewise, there has been a long tradition of research that has considered in some detail the impact of EIC administration on the colonial experience and post-colonial inheritance (Burke 1969; Marx 1969). In this last context, historians have explicitly linked the dynamics of private trade with British imperialism (Furber 1948; Marshall 1976, 1993; Saxe 1979; Watson 1980). Thus there exists a wealth of secondary materials documenting EIC financial structure, management, and organization, in addition to descriptions of the EIC's broad social, economic, and political impact in the East and in Britain. While we make use of these materials, they are not the focus of this article. Our concern is with the emergent structure of trade. To our knowledge, no previous studies have undertaken a systematic analysis of the *structure* of English trade networks in the East. By focusing on the EIC trade network we identify when (and how) a structure *for* globalization was put into place.

Distinct communities of historians have focused on British trade in the East. One group whose interests -- following Braudel (1972) -- center on the interaction of groups across bodies of water have dealt extensively with British trade as part of a broader pattern of trade and economic development in the Indian Ocean. This group stresses the replication of existing trade patterns and endogenous commercial development in the East and attribute British success to local partnerships and sheer presence, conceived in terms of the basic demographic aspects of trade -- ships, men, and ports (Arasaratnam 1995; Barendse 1998; Borsa 1990; Das Gupta and Pearson 1999; Prakash 1994; Saxe 1979). We consider and largely reject this demographic argument as insufficient. Here we show that the emergence of a densely embedded and tightly coupled trade network in the East -- under EIC control -- played the critical role in shaping EIC commercial

hegemony. This structure enabled the EIC to harness and increase information on prices, terms of trade, and commodities. This structure enabled the EIC to harness and increase information on prices, terms of trade, and commodities, facilitating coordination across poorly linked markets. Gains in communication were coupled by increasing capacity to build redundancy of supply, thereby insulating the EIC from stochastic market fluctuations. Equally important, these emergent network structures provided the social foundations for sustained trade, thereby enhancing already-established networks of eastern trade, through local partnerships already noted above.

A second group of economic historians and organizational scholars have focused attention on the considerable innovation within the EIC with respect to financial management and organizational structure thereby arguing that British hegemony in the East was the result of effective EIC strategy (Anderson, McCormick and Tollison 1983; Chaudhuri 1965, 1978; Steensgaard 1981).[2] There is partial truth to this idea; but the crucial transformation of the structure of English-East Indies trade, initially driven by company policy and orientation, persisted across striking changes in the company's fortunes, shifting patterns of European domination in the East, and sweeping changes in the Eastern political and social context. In contrast to historical accounts of the EIC, which stress the importance of internal directives for determining the course of English-East Indies trade, we show that the dynamics for change arose at the micro-level. Critical in this regard were the private trade interests of ships' captains, whose pursuit of profit from exchange led to the emergence of complex trade structures well beyond those envisioned by the EIC directorate. By focusing on the micro level, we are able to observe the development and elaboration of complex multilateral exchange circuits that give rise to densely integrated network components.

[2] Institutionalists rightly identify a set of London-based financial innovations, most importantly, the expansion of commercial instruments -- for example, the joint-stock company and insurance systems – as critical elements in the establishment of British commercial hegemony (Carruthers 1996; North 1990). As with the principally demographic models, the basic insight is correct. Solutions to capitalization and risk dilemmas made it possible for ships to be in the East. But the structure of trade networks in the East was not determined by capital investment. Our concern is with how actual trade networks emerge.

Roadmap:

The organization of this article is relatively straightforward. We first describe the relevant historical background for understanding EIC trade policy and expansion in the East. In 1680, the company withdrew from the internal eastern trade; by 1764 the EIC was positioned as the leading commercial force in the East, quickly thereafter emerging as a colonial power. The critical period for understanding the commercial development of a global market thus rests between 1680 and 1764. Much of this discussion focuses on the role of private traders whose activities integrated previously disjoint markets in the East. In order to disentangle structural features of the market from sheer scale increase, it is necessary to examine the constituent components of the English-East Indies trade -- the basic demography of trade. We focus on the carrying capacity (ships and tonnage) of the EIC and the number of ports actively involved in the trade network. We then map the structure of the trade network over time. We show that by the middle of the eighteenth century, the EIC was in the position to control a densely connected and tightly coupled trade network. We identify private traders -- EIC Captains who free-rode on company resources for private gain. We then demonstrate that the fully integrated global trade network was the by-product of private trading, thereby revealing how EIC management of Eastern trade created opportunities for malfeasance, and how, later, shifts in EIC policy constrained individual captains and provided the foundation for English colonial (versus trade) domination.

Historical Background:

A long history of trade linked the regions of Africa, Asia, Indonesia, and the Middle East before any known ship rounded the Cape of Good Hope. Europe participated in this trade, but as a marginal figure at distant remove by both land and sea. Before the sixteenth century, trade routes to Europe from the East involved long caravans across the deserts and plains. The prices of goods were significantly inflated to bear the expense of transportation, protection, and multiple transactions between merchants overseeing different portions of the route, and consequently Eastern goods arrived only sporadically and at enormous cost. In 1488, the Portuguese discovered

a safe passage around the Cape of Good Hope and began an overtly imperialist expansion into the East, conquering key ports in the Indian Ocean, notably Malacca, Macao, and Hormuz. While the Portuguese built up flourishing colonies, exacted concessions from merchants, and effectively excluded other Europeans from the area for a century, they had no significant impact on the existing patterns of trade in or across Europe and Asia, then dominated by Turks, Armenians, Javanese, Chinese, Bengalis, Arabs, Persians, and Gujaratis (Barendse 1998; Braudel 1982, p. 447; Chaudhuri 1978; Steensgaard 1981). As the Portuguese increasingly concentrated on the Americas, other Europeans ventured past the Cape. The Dutch were the first Europeans to have a significant impact on Eastern trade; and the British followed soon after. In 1600, the EIC was granted a royal charter of monopoly trade to the land east of the Cape of Good Hope and west of Cape Horn. Five years after the first Dutch penetration, the first fleet set out in 1601.[3] At its conception, the EIC was by far the largest and most ambitious merchant association yet conceived in England. By 1657, the EIC was a joint stock, M-form organization with permanent capital, regular stockholders' meetings, and a large administrative bureaucracy.

Getting to the East was only half the battle. Once past the cape, vast profits were possible, but the uncertain eastern markets produced endemic fluctuations in return. We can distinguish three general periods; 1600-1680, 1681-1764, and 1765-1835. Until 1680, the EIC struggled to establish effective communication; stable infrastructure and routine supply chains. The impact of these persistent organizational weaknesses limited the EIC's capacity to respond to rapidly shifting market conditions (Basset 1960; Toussaint 1966). Consequently, what loomed

[3] Technically, this is the first incarnation of the EIC. The second incarnation resulted from a political and economic dispute over the monopoly rights of the company and the granting of seats on the General Committee, during which a second company was able to begin the process of establishing itself in the Indies. With leverage born of capital investment, exclusive knowledge, and squatters' rights, the original EIC was able to force the merger of the two firms. The United Company resulted from this merger. An excellent description of the events surrounding the merger in London appears in Carruthers (1996). Related events in the East, which mostly consisted of existing factors excluding the new company traders from markets, is described in numerous histories of the Company (Keay 1991; Lawson 1993; Wilbur 1945; Williamson 1953). Since the result of the merger had more to do with dispersing profits of the Company over a wider pool of London elite than reorganizing trading relations, we do not distinguish two separate companies, especially since the board of the first was carried over into the board of the second.

large in England loomed meager in the East. Throughout the seventeenth century, the EIC was a poor cousin to the Dutch East India Company (VOC), itself struggling to establish a place along side the empires and merchant networks in the East, across central Asia, and into the Mediterranean (Adams 1994, 1996).

Following the Dutch, the EIC first tried to supplement their limited capital with profits derived from trade within the East. To this end, EIC ships were directed to piggyback on existing trade opportunities in the Indian Ocean, to participate in the "country trade." For example, cotton goods bought in Surat would be sold for profit in Batavia, providing extra funds for the purchase of pepper, then viewed as the most profitable commodity imported into England. Following this strategy throughout the seventeenth century, the EIC lagged after the Dutch in investment and profit (Adams 1996). More problematic, EIC involvement in the country trade led to continued market instabilities in England. Between 1667 and 1679, in an effort to routinize the home market, and reduce exposure in the East, the EIC gradually withdrew from the country trade. By 1680 the EIC formally abandoned intra-regional trading -- which was left to individuals (Marshall 1993).

After 1680, when the EIC had withdrawn from the country trade, commercial opportunities within the East were numerous. Although the endogenous country trade in the East was significant and commercially sophisticated throughout the seventeenth and eighteenth centuries, it was fragmented into largely disjoint markets. This had not always been the case; Eastern trade systems were previously much more tightly integrated and the penetration of Europeans contributed to a process of fragmentation already underway as a consequence of the decline of the Muslim Sultanates and withdrawal of Chinese-sponsored foreign trade. By 1680, the Eastern trade system was dispersed and loosely-jointed, split between markets serving China and those centered on the Indian subcontinent, further divided among isolated merchants loosely

tied to geographic bases[4]. For example, Gujaratis dominated the trade across India and Bugis operated in the Indonesia archipelago. Between 1681 and 1764, structural holes resulting from this regional clustering were bridged by English captains free-riding on EIC resources in pursuit of private profit.

By the mid-eighteenth century, the EIC was firmly established as the largest commercial interest in the East. Eventually, two different dynamics would snuff out the illegitimate private trade of captains. First, following the battle of Plassey (where the English defeated the Mughal Army) in 1757, the EIC began to lay the foundations for their colonial empire. Consequently within a decade, the company with enhanced access to vastly increased resources operating within a new institutional structure was capable of exerting effective control over its now robust trade network, thereby stamping out opportunity for captains. Second, free riding became simultaneously less lucrative. As the EIC monopoly weakened, the East was increasingly flooded with other actors[5]. Captains free-riding on EIC resources no longer held a distinct competitive advantage. The critical period therefore, rests between 1681 and 1764, a time when a fully integrated trade network emerged. And in this period, the critical actors were private traders.

Principals, agents, and private trade

In theory, directors of the EIC sent ships to factories (warehouses where goods were stockpiled over the trading season) operated by merchants, known as factors, who managed the company trade through local brokers. Ships delivered the capital necessary for trade and once loaded with goods were dispatched to England. These simple operations in the east were spatially

[4] These structural features are recorded under various names, for example, "systems" (Lombard 1981, p. 181), "networks" (Marshall 1993, p. 294), "commercial regions" (Chaudhuri 1978, p. 193), "worlds" (Braudel 1982, p. 533), "a network of inter-connected systems" (Arasaratnam 1995, p. 15), "interlocking circuits" (Barendse 1998, p. 5), and adjectives, for example, "dispersed", "loosely-jointed" (Das Gupta 1999, p. 42), multi-polar (Borsa 1990), and segmented (Prakash 1997, p. xvi). Within communities, organization was typically limited to solitary enterprise or limited contractual partnerships such as *respondentia* and *commenda* (Das Gupta 1999, p. 129; Arasnapatam 1995, p. 9).

[5] The loss of EIC monopoly control over trade in the East following colonialization always seems counter-intuitive at first. In England, free market agitators (Smith and Burke, for example) became more powerful, and the company -- now a colonial power -- came under greater public scrutiny. Erosion of monopoly control followed shortly.

and temporally distant from England, often 6,000 miles -- effectively six to eight months -- from any central authority. Thus years would pass before the possible implementation of punitive measures in response to reported agent malfeasance. Likewise, market information was severely delayed before reaching London. Employees were the main conduits of this information, leading to pronounced information asymmetries. Market uncertainty and information asymmetry meant that the EIC could not easily evaluate underperformance or identify self-interested action[6]. Consequently, EIC employees, captains and factors -- once in the east -- were necessarily operating with relative autonomy. This relative autonomy meant that principals' control over agents was difficult to resolve.

In the absence of control, rational agents pursue their own private interests, most often free-riding off of collective resources provided by principals. The form this free-riding typically assumed was private trading, which was pervasive in all European companies operating in the East and was considered a significant threat to both the internal operations and the viability of the various national monopolies.[7] The private trade had three illegitimate aspects -- corruption, smuggling, and free riding. We consider each in turn. Corrupt factors frequently abused local privileges by engaging in private trade under terms of taxation granted to the corporate body, competed directly with EIC trade, "borrowed" company funds to float trading ventures, and devised various methods of embezzlement. Officers and crew, allotted limited amounts of cargo space for their own personal inter-continental trade, often illegally supplemented their allotment in order to smuggle additional goods into England. Smuggling and corruption are best seen as opportunistic trimming, reducing company profit but not seriously impacting the dynamics of

[6] Compounding the problem was the fact that ship officers carried market information prepared by factors to the EIC directorate. The close quarters of officers over long periods of time were likely associated with enhanced capacity to collude. Similar dynamics underlying agent opportunism are identified by Kiser (1994; Kiser and Tong 1992).

[7] As Jones and Ville (1996) note, company histories for the EIC, Hudson Bay, Royal African, and Dutch VOC, among others "provide abundant evidence of persistent opportunism" and sustained, but largely unsuccessful, attempts to counter agent abuse of autonomy.

trade (Jones and Ville 1996a, Carlos and Nicholas 1996). Neither corruption nor smuggling challenged the capacity of the EIC to direct the acquisition of Eastern goods.

In contrast, when captains and officers actively engaged in the country trade in order to garner profit for themselves at company expense, the system by which the EIC procured goods was significantly distorted. This is the trade we consider in this article, simply because with respect to the organization of Eastern trade networks, the private trade of Captains was by far the most important.[8]

The EIC directorate recognized that classical solutions to the principal-agent problem -- partnering within kinship groups, coalition formation, ransoming close relations -- were not easily adaptable to the increased scale and span of control of their activities in the East (Van Dooselaare 2004; Grief 1994; Lovejoy and Richardson 1999). Likewise, early EIC solutions to the principal-agent problem – oaths and bonds — failed to induce employee compliance in the face of short-term contracts, an experience subsequently repeated by the Royal African and Hudson Bay Companies (Carlos 1992).[9] The persistent lack of resources and competition with the Dutch VOC led the EIC to adopt cost-cutting measures -- abandoning the intra-Asian trade, abandoning surveillance of employees, leasing ships, and insufficiently supplying factors with bullion. Part and parcel of this retrenchment was the adoption of a strategy of employee appeasement as a solution to the principal-agent problem (Chaudhuri 1978).[10]

One central element of the appeasement strategy adopted by the EIC shaped the densely embedded and tightly coupled trade network in the East we observe here. Officers and seamen were allotted sizeable portions of the cargo hold for private goods when traveling between East

[8] Factors' participation in Eastern trade has been the subject of much attention. But, this participation followed existing trade routes, replicating already-established networks. The private trade of Captains operated across the gaps in the existing local trade. The activities of factors were important for the subsequent establishment of British colonial rule, a topic beyond the scope of this paper.

[9] The English were not alone in failing to control agent activities. For example, Adams documents the breakdown of the Dutch company's control measures as a consequence of the EIC's multiplication of remittance paths available to employees in the East (1996).

[10] These concessions have been considered by both contemporaries and economic historians a reasonable if initially unintended solution to the difficulties of recruiting men to low-paid, life-threatening positions. EIC mortality rates fluctuated between 15 and 20% per sailing season (Degryse 1995).

Indian ports. This created an accidental, or perverse, incentive for captains to deviate from official voyages and prolong their stay in the East in order to gain from their private investment in the country trade (Anderson, McCormick and Tollison 1983). Ultimately, failed EIC solutions to the principal-agent problem induced the macro-structure we observe.

Ironically, ex post, imperfect control over captain's and ships led to long-term gains for the company. Against this background, we consider the possibility that either EIC directors recognized potential gains from malfeasance and strategically implemented an incentive structure to encourage private traders, or having stumbled upon this arrangement, purposely failed to apply appropriate enforcement measures. Both are unlikely for two reasons.

First, the company records and correspondence are filled with exhortations for captains to proceed with "quick despatch" and "speedy passage" as well as complaints about ships having missed the seasonal passage around the Cape of Good Hope (East India Company 1689; Chaudhuri 1978). These complaints were motivated by the significant short-term losses to the company arising from delays that caused irregularity in the delivery of goods. In addition to problems of supply, the EIC leased their ships and paid demurrage fees for delayed voyages. Costs associated with demurrage likely accounted for up to 36% of the total profits within sailing seasons (Chaudhuri 1993). Second, the EIC regularly attempted to bypass contractual limits to their control by offering gratuities to timely captains and were only able to fully reform the process by which captaincies were bought and sold, thereby correcting the adverse selection problem, in the 1780s -- that is, after the private trading period (Anderson, McCormick and Tollison 1983; Cotton 1949).[11]

Throughout the period from 1660 to 1780, the EIC directors perceived the purposeful delay of voyages as malfeasance and aggressively sought to curb these activities, succeeding only when the environmental and contractual obstacles to the exercise of their authority were

[11] Initially, ship owners of vessels leased by the EIC retained the right to sell the captaincy as a transferable and inheritable good, thus severely limiting EIC capacity to enforce regulations.

overcome in the late eighteenth century. While always attractive to imagine that successful strategies that emerge ex post were perceived ex ante, the evidence in this case strongly suggests otherwise. EIC directors may have been ahead of their time, but they were not prescient. Of course, it is also the case that the interesting question, and the one we pose here, is not whether the EIC intentionally or unintentionally induced the network structure we observe but rather *how* variability of control within the EIC altered this structure. This is the focus of the next section.

Free-riding, self-interest, and connected markets

It is generally thought that when employees exploit access to company resources and deploy these resources for their own benefit -- free riding on collective goods -- negative outcomes result. Since Smith, critics of monopolies have argued that the monopoly form nurtures corruption and rent-seeking behavior. Thus, in 1776, Smith noted the collective cost carried by the English arising from "the extraordinary waste which the fraud and abuse, inseparable from the management of the affairs of [the EIC], must necessarily have occasioned." This work precipitated a discussion that has dominated British political economy and economics for generations, pitting free trade advocates against supporters of monopoly rights (for history of the debate cf. Barber 1975; for recent instantiations, cf. Carlos and Nicholas 1996; Jones and Ville 1996a 1996b). This article suggests that the dichotomy may be false.

Following Smith, in this article capitalism is conceived of as a self-organized system of self-interested actors pursuing individual gain. In the East India case considered here, self-interested actors pursing private gain within a corporate framework, engaging in Smith's fraud and abuse, produced a connected market with benefits for all participants. Malfeasant captains built on and elaborated the stable infrastructure of the EIC, bridging the regional clusters that the EIC had earlier reproduced through participation in the country trade. The unintended consequences of the EIC's loss of control created the characteristic features of capitalism, well-connected buyers and sellers.

Similar dynamics are found elsewhere. The finding that informal ties are crucial to the process of stabilizing trade networks and integrating markets supports historical work on the pre-modern organization of long-distance trade, specifically, the construction of interlocking substructures facilitating the growth of capitalism (Braudel 1972 1974; Granovetter 1985). Likewise, a number of works have emphasized strong ties and redundant contacts (networks, coalitions, guilds, prestation chains, and multi-divisional firms) as solutions to distance-based agency problems (Anderson, McCormick and Tollison 1983; Curtin 1994; Greif 1989; Grofman and Landa 1983; Hage and Harary 1991). These works identify why cohesion and redundancy solve the extreme agency and trust problems posed by long-distance trade, exacerbated in eras of slow transportation and communication.

Here we identify the dynamics underlying structural cohesion of an emergent global trade network in the East, tracing its production to a loss of control that multiplies external contacts, thereby securing steady supply streams and lowering prices through communication across markets. Central components of this argument include the possibility of persistent localism through bureaucratic processes (Bearman 1991; Savage, Stovel and Bearman 2001) and the importance of organizational flexibility in uncertain environments (White et al. forthcoming; Piore and Sabel 1984; Weick 1976). Considered as such, the decentralization of EIC trade and organization into the hands of the private traders supports the observation that marginal actors generate essential innovations (Boorman and Levitt 1973; Burt 2004).

Data:

Data for this paper arise from *The Catalogue of the East India Company's Ships' Journals and Logs, 1600-1834* and *The Biographical index of East India Company maritime service officers: 1600-1834*, sources which integrate the journals, logs, ledgers, imprest books, pay books, receipt books, absence books, company papers, and voluminous correspondence of the Company relevant for each ship and employed officer. From the first volume, we have a complete list of the 1,480 ships (4,725 voyages) that were engaged in EIC trade from 1601 to 1835. Eighty-

five percent of the entries for voyages contain a complete set of ports visited with dates of arrival and departure.[12] All ships list the trading season in which they were active and 99% percent include the intended destination. Less systematically, there is information on ship tonnage, dimensions, crew size[13], armaments, principal owners, and shipbuilders. In the analyses reported below, ports fall in and out of the network. Ports not visited within a four-year period are considered inactive. Throughout, we follow convention and refer to a complete round trip by the term *voyage*, a journey to the destination port without returning as a *passage*, and reserve *trip* for the individual port-to-port hops that make up both passages and voyages. The level of detail included in the data set allows a day-to-day recreation of the location of ships (through reference to arrival and destination ports), which spans 85,838 days from the granting of the royal charter, December 31, 1600, to the return of the last ship, the General Palmer, on March 3, 1835. Throughout we analyze the structure of trade for four-year periods determined by the departure date of each voyage. This allows us to identify structural change over time, while retaining a sufficient number of ties connecting ports to reliably measure structural properties.[14] This means that a ship that began its voyage in 1701 and continued to travel until 1705 is included in the 1700 observation period only. Data on ships and voyages is complemented by detailed career histories for all (12,000) EIC crew on ships who attained the rank of 6th mate or above. For all officers, we retain data on prior voyages. For each voyage, we use these data to build a complete crew list. We use this information to construct a measure for regional experience.

[12] Of the missing 724 voyages, 188 were terminated due to rotting, wreck, acts of aggression, and other misadventures. 117 voyages are missing port data for the period focused on here, from 1680 to 1764.

[13] Both crew size and tonnage were underreported. Since the EIC had to pay additional fees when crew sizes exceeded one hundred men, the modal crew size reported is ninety-nine, even when absurd with regard to the necessities of running a ship. The absurdity is obscured in voyages where the EIC reported a tonnage of 499 in order to avoid a decree requiring the presence of a chaplain on board ships over 500 tons (Cotton and Foster, 1949).

[14] Individual voyages yield networks too sparse for analysis, and partitions across time yield calendrical cross-sections that split voyages. Comparable analyses for 2-year windows (available from the authors on request) show similar results as those reported here.

The "demographic" picture:

As background, we describe the simple demographics of the East Indian trade, conceived as the descriptions of the fundamental units of trade, ships and ports. These indicators the reflect development of the company over time as typically described by historians. The unsteadiness of the period leading up to 1680 transforms into steady growth during the period of greatest company prosperity, from 1680 to 1760, leading into the rapid increase in investment after 1770, and the beginning of colonial entrenchment. Here we focus on the number of ships setting out to sea, average tonnage, and number of active ports over the whole period from 1600 to 1831.

Figure 1 about here

Results are reported in Figure 1, for four-year periods. Figure 1 provides strong evidence of increasing intensity of contact, peaking with respect to number of ships in the late eighteenth century. This peak occurs after the EIC establishes commercial control over the East -- having out competed the Dutch VOC. Over the same period, ships' size increased almost continuously. At the turn of the nineteenth century, the typical boat was two to three times larger, in terms of carrying capacity, than the boats of the early seventeenth century. Subsequent declines in numbers of ships are mirrored by significant increases in average tonnage. The number of active ports jumps sharply in 1680 and remains at high levels through the middle of the eighteenth century; declining sharply thereafter. After 1760, more ships went to fewer ports as the EIC exerted more control over the activities of captains. The period between 1680 and 1760 -- when private trade was at its peak -- thus appears as the critical period for the EIC expansion into, and solidification of trade, in the East. Throughout, the company's largest exports were gold and

silver bullion. Imports consisted mainly of pepper, cotton goods, silk wares, tea, coffee, chinaware, and opium.[15]

Analysis:

Here we describe how we convert ships routes into networks. Network data are constructed over time to reflect the passage of ships from port to port. Nodes represent ports visited and arcs represent (schematically) ships' routes: adjacent nodes are linked by trips. Arrows indicate the direction of travel. This process yields a graph of equally weighted ties directed according to the path of the ship that can be split into any number of horizontal cross-sections. As noted earlier, we aggregate these data into fifty-eight four-year seasons determined by the opening date of a voyage.

Figure 2 [Panels A, B, AND C] illustrate how we compose a network, using as an example the voyages of three ships that sailed in the 1720 season, the *Prince Augustus*, *Lyell*, and the *Princess Amelia*. A quick glance at each panel reveals that ports (indexed as small circles) are displayed according to latitude and longitude. The Indian sub-continent is visible in Panel a. In the upper-left are mid-east ports. In Panel b, the Indonesian archipelago to the south (bottom right) and China (top right) are visible. Lines linking ports schematically represent the boats' voyages.

Figure 2 [Panels A, B, and C] about here

Panel A charts the travels of the *Prince Augustus* which departed England 25 November 1722, arrived in Mokha on 3 June 1723, cycled between Mokha and Bombay, headed for Surat, proceeded down the Malabar coast to Cochin, and returned to England. Panel B includes the voyage of *Lyell*, which sailed directly to Batavia (now Jakarta), went to Whampoa (now

[15] These commodities were traded alongside a bewildering variety of goods, enumerated in lists lasting many pages. A short sample might include diamonds, rubies, rose attar, shiraz, dragonsblood, cardamom, lac (an insect byproduct), galls (little homes made on oak trees by insects), rose maloes, sal amonniac, assafoetida, bezoar, and brimstone.

Guangzhou), returned to Indonesia, and proceeded home. In Panel C, we include the *Princess Amelia,* which cycled back and forth between ports, visiting Banjarmassin, Batavia, Mokha, Bombay, Tellicherry, Amoy, Whampoa, and Malacca, crossing paths with both the *Prince Augustus* and the *Lyell,* thereby linking the disparate market clusters of the East into one large component. For each trading season, we induce graphs of linked ports by pooling voyages sent out under the auspices of the EIC. The resulting graphs provide snapshots of the structure of trade for each period. In what follows, we analyze the structure of these graphs, to provide insight into the dynamics of change.

Structure over Time:

The transformation of the structure of the EIC network is shown in Figure 3, Panels A-E, which report the complete network for five trading seasons, 1620, 1660, 1720, 1760, and 1820; covering the entire period of EIC engagement in the East. As before, ports are circles located with respect to latitude and longitude, voyages are represented as lines.[16]

Figure 3 [Panels A-E] about here

As shown in Panel A, by 1620 the company was heavily involved in the country trade. The cohesive network linking Indian, Indonesian, and Middle Eastern ports reflects this engagement. As is also evident, direct trade with China was not yet established. By 1660 [Panel B], the EIC was facing severe financial difficulties exacerbated by political turmoil in England and aggressive business tactics of the VOC, the more powerful Dutch East India Company. Against this background, the EIC withdrew from the country trade; consequently their footprint in the East was significantly reduced. Substantial growth and expansion was evident by 1720 [Panel C]: integration increased and the geographic reach of the network had expanded to the Persian Gulf, up through Indonesia and into the far Eastern markets of Malaysia and China. Behind this radical

[16] Across each panel, some lines appear darker and thicker than others. Here lines are not weighted by number of voyages; line thickness and dark regions of the graph indicate densely proximate routes.

transformation lay intense engagement of private traders with the country trade. By 1760 [Panel D], at the end of the private trade period, the EIC trade network had fully integrated the previously separated trading regions of the East, linking the Red Sea, Persian Gulf, West India, Bengal, Ceylon, Indonesia, Malaysia, Philippines, and China through numerous redundant paths across ports. EIC central consolidation and control are evident by 1820 [Panel E]. The number of paths and regions were drastically reduced as the EIC's trade became focused on major ports within the territorial domain of the British.

Micro-level processes:

We now turn to understanding the dynamics associated with the radical expansion and solidification of the EIC trade network in the period from 1680 to 1760, revealed in Figure 3, Panels A-E. In this period, the EIC acquired a dominant position in both local and overseas trade, and thereby transformed the structure of the global trade networks in which East-West trade was organized. Here we show that the emergence of a dense, fully integrated, global trade network rested on the illegitimate behavior of Captains, seeking to profit from private trade.

The first difficulty lies in identifying private trade voyages. Captains engaged in the illegitimate diversion of EIC resources for private profit didn't document their malfeasance for company records.[17] Consequently, we use voyage characteristics to identify private trading. The trace of private trade is revealed by the intersection of *voyage duration and cycling*. As noted above, private trade was illegitimate when captains diverted corporate goods from their intended ends. Thus, free riding could only occur when captains "deliberately 'los[t] the season' for their return voyages to Europe by moving in a dilatory fashion from Bombay to other Asiatic ports, investing and reinvesting their 'privilege[18],'" (Fitzgerald 1777; Furber 1948, p. 280; 1976, p. 195; Watson 1980, p. 71; Anderson, McCormick and Tollison, 1983, p. 478). Ships were expected to stay in the East for six months. Here, presumptive free traders are on voyages whose duration

[17] Historians, for example, have not found confessional post-its in company books documenting engagement in private trade. Nor have we.
[18] The privileges referred to here are the officer's allotment of cargo space on EIC vessels, described above.

exceeded average duration for each sailing season, measured from time of arrival at the first port in the East Indies to time of arrival at the last port in the East Indies.[19] Most of the ships identified as private traders stayed in the East for more than a year.

Private traders engaged in the country trade, buying goods in one port and selling them in others; thereby linking otherwise disjoint Eastern trade regions. In contrast, EIC directed voyages left England for ports where English factors waited with goods for return shipment. When boats went from one port to another in the East, they did so either to participate in the private country trade, or to procure new goods for freight back to England. Because time was of the essence, captains engaged in legitimate EIC trade would not double-back to previous ports, thereby inducing cycles within their voyage. The main purpose of cycling was trade, and the traders in the East -- after the EIC pulled out of the country trade -- were private traders. Consequently, voyages with cycles are considered presumptive private trade voyages, where a cycle is defined as a path that brings a voyage back to a port previously visited.[20]

Protocols varied across ports; each had its own set of officials, who required custom duties, gifts, and bribes with varying degrees of specificity and ceremony. Norms varied significantly across trading regions; experience on the Indian sub-continent was not easily transposed to Indonesia, or China. Captains and crew engaged in EIC trade were able to rely on institutional knowledge to negotiate these complexities. Private traders shouldered greater risk and lacked the institutional safeguards in place for legitimate voyages. Consequently, private traders had to rely on their personal experience in order to pursue commercial opportunities.

[19] This measure avoids bias arising from a steady decrease in the duration of trips and variability due to fluctuations in the weather. The decrease in mean voyage duration over time was driven less by technical innovation than increased control of the EIC over trade routes (Menard 1966; Steensgaard 1965).

[20] The EIC did however occasionally let out the ships for local freight voyages. For example, in 1702, the *Colchester* was leased to an Armenian merchant (Sarhad Israeli) to take goods to Balasore and Bandar Abbas from Madras; sometime later the *Hester* was leased (by Janardhan Seth, a Hindu merchant) for a similar freighting voyage (Prakash 1994). To avoid including such trips, we exclude voyages containing only cycles of length two -- that is, cycles involving only two ports, e.g.: A↔B. Neither the Hester not the Colchester, for example, are coded as Private Voyages. Some private trade voyages also had freighting elements, although even this was unusual. For example, Barlow's second voyage on the Kent, in which there seems to have been both private trade and freight carrying, is an exception (Barlow and Lubbock 1934).

Since prior experience in the East was critical for negotiating private trades, it follows that captains engaged in the private trade ought to have had more experience specific to the destinations of their current voyage than captains pursuing legitimate trade. We assess our indicator of private trade -- voyages characterized by cycling and extended duration -- by generating an experience measure for captains, specific to each voyage undertaken. Presumptive private traders ought to have had wider prior experience. Table 1 reports the association between experience and private trading, reporting a count of the number of distinct regions previously encountered by a Captain, for each target voyage, for all voyages which set out from England between 1680 and 1760 -- the period where private trade was possible.

Table 1 about here

The results of Table 1 show that Captains of private trader voyages are more likely to have had greater levels of regional experience tailored to their current voyage. Note that inexperience in the East is strongly associated with extended duration. Captains without experience were much more likely to miss sailing seasons than those whose previous tenure in the East was substantial. Thus, this assessment is conservative -- the strong association between private trading and experience, for those with experience, is striking, offering construct validity for the private trade indicator. Consequently, in subsequent analyses private trade voyages are those characterized by cycling and excessive duration.

The impact of private traders on the structure of trade in the East

We now consider the effect of private traders on the macro-structure of British trade in the East. Our strategy is simple. We assess the impact of the private trading voyages on the macro-structure by removing these voyages from the network. This returns a new graph of the overall structure, which we refer to as the *private trade removed* graph. This graph is the graph of the network without private traders. Naturally, by removed directed arcs, we reduce the density of the original graph. Thus the differences between the *private trade removed* graphs and the

complete graphs are possibly artifactual. To ensure that our results are not an artifact of arc deletion, we return to the original data structure, which included private traders and all other voyages. From the set of all other voyages, a voyage matched on destination for each private trade voyage is selected at random. These are identified as "matched voyages". We remove from the complete data set voyages matched to the private trade voyages. We label the resulting graph the *matched voyages removed* graph. This graph includes but is not entirely composed of, the private traders. Since we removed comparable voyages, we can directly assess impact of the private trade on the macro-structure without fear that differences are artifactual. In fact, one can easily conceptualize private trade characteristics as a treatment affecting network construction, allowing a comparison between the macro-level structure of networks subjected to treatment with the structure of a networks serving as a control set. For convenience, the *private trade removed graphs* -- those lacking voyages with private traders -- can be thought of as the control group. The graphs with matched voyages removed can be considered the treatment group. One can see the effect of private trade in the graph with matched voyages removed. Likewise, there can be no effect of the private traders on the graph with the private trade voyages removed. But it is more intuitive to think about the effect of private traders on the macro-structure by focusing on what happens to the structure when they are removed from the network. This is the approach we take.

Figure 4 [Panels A-E] show the macro-structure for the trade network at the start, middle, and end of the private trade period -- 1680, 1712, 1720, 1728, and 1760. Each panel allows comparison of the structure of the legitimate graph and illegitimate graph, revealing the impact of the private traders on the network[21]. For reference, the complete trade network for each period is also shown. Ignoring a single exploratory voyage to Madagascar in 1760 (indicated in the bottom left of the completer trade network for 1760, Panel E), over the whole period, the complete network is a single interconnected component. Of interest then is the effect of private trade on the

[21] Here we position ports using a standard spring algorithm widely used and available in Pajek, in order to better reveal the structural comparison. Note that the partitions in the *private trade removed* graphs occur across regions; for example, in 1720 the partition lies between the Western and Eastern Indian Ocean.

component for each period. Focusing first on 1680, at the start of the private trade period, it is evident that the matched voyage removed and private trade removed graphs are essentially similar. In marked contrast, the impact of private trading on the macro-structure is strongly evident in the middle of the period. The graphs for 1712, 1720, and 1728 [Panels B, C, D] show that without private traders, the entire system of EIC trade in the East is decomposed into two disjoint components. By 1760, as the EIC reasserted control over the trading activities of Captains, the effect of private trade is muted, but still visible. A single port connects two otherwise separate regions.

Figure 4 [Panels A - E] about here

Network integration

In Figure 4, the absence of graph connectivity at the peak of private trading in the legitimate trade graphs is visually obvious. The key impact of private trading was to knit together otherwise disconnected regions. In order to capture the extent of network integration directly we must take into account both the number of discrete components and the proportion of ports within those components. To do this, we invert a standard measure of heterogeneity, specifically $Heterogeneity = \sum_{i}^{n}[1- (a_i / z)^2]$, where a represents the number of ports in component i, and z represents the complete count of ports in the network (Finke and Stark 1988). To understand how this works, it is important to realize that a connectivity level of one means that all of the nodes (ports) are integrated into a single connected component; a connectivity level of two means that all nodes are integrated into a single connected bicomponent. We use $H = \sum_{i}^{n}(a_i / z)^2$, so that an increase in integration pushes the measure closer to the next connectivity level, for example from fragmentation to a single component $(0 \rightarrow 1)$, or from a component to a bicomponent $(1 \rightarrow 2)$.

Figure 5 reports integration scores for the complete network, for the graphs with private traders removed and for the graphs with matched voyages removed.

Figure 5 about here

Higher scores index greater integration. As is evident from Figure 5, the total trade network from 1680 to 1760 is almost always a fully connected component. In fact, regions of the total network are densely interconnected, yielding integration scores well above one. The graph with the matched voyages removed is always more densely integrated than the graph with the private traders removed. The snapshots shown in Figure 4 visually indicate the role of the private traders in integrating the East Indian trade network. Figure 5 demonstrates that the visual impact is real – not an optic artifact. Private trading voyages' contribution to integration is significantly greater than the contribution of the matched voyages. Without private traders, the graphs fragment into large regional clusters dislocated from the main component

Standard network indices:

The integrative effects of the private trade are also evident in standard measures of network structure, including graph density, size of the largest component, and size of the largest bicomponent. In Figure 6, we report these results. For each, observed measures for the private trade removed and matched voyages removed graphs are first subtracted from observations taken on the total network. We then calculate each measure as a percentage of the total network -- that is, their impact. Relative impact, reported in Figure 6, is the ratio of private traders impact over other traders. Where values exceed one, private traders have greater relative impact on network structure than the matched voyages. This is the case for each variable at each moment in time.

Density is simply the number of trips between ports relative to the total possible trips between ports. Consequently, a measure of weighted density mainly captures the increase in the number of ships at sea. To avoid this, we calculate the density of the directed binary port-port network. Ships may set out from one port and return -- in cases of bad weather or other similarly

unpredictable events. We do not include these loops in the measure of density since self-ties have no substantive meaning in this context. As is evident above, private trade typically accounts for more than five times the density accounted for by the legitimate voyages. This means that in addition to linking regions, the activity of private traders significantly enhanced within region contact, thereby building multiple robust channels for the transmission of information on prices, terms of trade, and available commodities.

In addition to building within-region network infrastructure and cross-region trade networks, private traders directly incorporated markets into the existing network. The impact of private traders on network size (sheer count of ports) is consistently strong. This suggests that the process of establishing and sustaining ties to numerous markets was an ongoing byproduct of the pursuit of the private trade. In fact, private traders are 2 times more likely than other Captains to discover new ports, subsequently integrated into the English East Indian trade network.

Finally, Figure 6 considers the impact of private trade on the number of ports embedded within the largest bicomponent. Recent work on large complex networks (Moody 2004; Moody and White 2003; White and Harary 2001) has shown that bicomponents provide the best measurement for assessing embeddedness and structural cohesion. In addition, networks that evidence structural redundancy -- revealed through identification of graph bicomponents -- are significantly less vulnerable to stochastic (or purposive) disruptions. This structural element is critical for market contexts in general since uninterrupted delivery of goods and information is central for efficient market clearing, and in the East (and pre-modern markets) especially so, given striking temporal and spatial discontinuities. In addition, the presence of bicomponents eliminates information asymmetries that often arise in star-networks -- identified by Adams as one of the principle reasons for Dutch decline in the East (Adams 1996).

Discussion:

In 1738, Henry Kent set off on his first voyage with the EIC -- as second mate on the Somerset, destined for Benkulen. Eight years later, in 1746, now Captain of the *Dragon*, en route

to China, Kent sailed through the Indonesian Archipelago, and landed twice at Tamborneo, a port presumably on or near Borneo *never* previously (or subsequently) encountered by any of the other 4572 EIC voyages to the East, between 1600 and 1831. After this trip, Kent sailed twice to India, with stops in Madras, Calcutta, Culpee, and Benkulen. On these voyages Kent cycled between ports, but never missed a sailing season, returning to England roughly twenty-six months after departure. By 1752, Kent had sailed through -- on different voyages -- the entire East.

On his last voyage as Captain of the *Dragon*, Kent left Downs on the 16th of November 1752 destined for Bengal. He made good time, arriving at the Cape in early February. By the 24th of March, the *Dragon* sailed into St. Augustine's Bay. Rather than proceeding directly to Madras, Kent went up the coast of Madagascar to Morandava. From April to July, Kent stayed at Morandava, where among things, he helped establish a factory, exchanged guns, ammunition, and alcohol for meat, water, and slaves; exchanged brandy for a young female slave with the King and Queen of Madagascar who had traveled to meet him with their retinue, built slave quarters on his ship, brought on board seventy-four slaves, dealt with mutinous crew members -- three of whom were caught deserting in the ships' longboat -- crushed a small slave revolt, and met up with a boat on the EIC register (the *Swallow*, leaving Downs within days of the *Dragon*, captained by John Bell, also taking his last trip, for which no existing voyage data are available in EIC records) carrying seventy-one slaves picked up elsewhere, and took them on board in exchange for items not recorded. Leaving Morandava, Kent made a brief stop at the Morungary River (alternatively, Massalege, now possibly Mahavavy), before setting sail with slaves on board to Madras. Once in Madras, Kent traveled to Calcutta, Culpee, returned to Madras, completing a cycle, before sailing for Benkulen, and cycling back to Madagascar. Along the way, he missed his sailing season, forcing him to stay in the East an extra year, and thereby incurring additional costs to the EIC. What Kent did with the slaves we don't know.

Over the course of his career, Kent led legitimate and illegitimate voyages. Like other private traders, Kent discovered, and twice returned, to a new port, and thereby opened up

potential new markets for the EIC. On the voyage described above, Kent engaged in the slave trade, exchanging arms for slaves, and collecting slaves picked up and transported to Madagascar -- a haven for pirates -- by an EIC vessel (the *Swallow*) for which no voyage data are available. He did this at a time when the EIC was not engaged officially in the slave trade. The circuits he took wove together the Bengal trading region with the Indonesian archipelago, and the vibrant trading world of the East coast of Africa. Only rarely can one see from our records into the world of the private trader as clearly as for Kent, but the trace of their activity is visible -- long stays in the East, and cycles between ports. To see this, one has to construct trade networks amenable to structural analysis. The paths of the ships constitute the transportation and communication infrastructure of firm operations. The records of the voyages provide a material trace of the system of exchange involving the English company merchants. Here, we use these paths to induce an image of the company trade over time thereby allowing us to disentangle the legitimate company trade from the illegitimate private trade pursued by company employees.

In 1776, Adam Smith argued that the motor for developing trade across separate societies resided entirely in the local interaction of individual participants. In the EIC context, this line of argument suggested that the private traders -- those operating across multiple market arenas -- provided the impetus for successful trade, weaving together exotic locales into a global market spanning the Eastern seas. In this version of the story, the monopolistic EIC rode the backs of these entrepreneurial individuals, reaping undeserved profit from the market-making activities of their employees. A free-market would have been better; the monopoly form only fettering the pure expression of the English entrepreneurial spirit.

The evidence presented in this paper suggests a more complex process. First, the private traders were engaged in malfeasance. Second, the opposition between free-market entrepreneurs and monopoly organization neglects the fact that market making requires an institutional foundation. Private traders didn't triumph alone. The private traders needed the EIC infrastructure as foundation, just as the EIC needed private traders for expansion and integration. EIC

employment provided captains with distinct competitive advantages through access to greater resources -- big ships, money, captive crews, factories, protection from duties, and security on the seas. These advantages made it possible for private traders to get action and make money.

At the same time, the EIC benefited from through distribution of the risk involved in expanding markets in the East. In 1680, confronted with clear evidence that English interests were falling behind those of the Dutch, the EIC pulled out of their direct involvement in the country trade. Ironically, this decision enabled the EIC to consolidate and integrate Eastern markets, expand their reach into the East, and heighten the internal transmission of information on prices, goods, and market practices. When the EIC pulled out of the country trade they did not envision that within eighty years they would dominate the East. But this is what happened. Expansion and integration in the east was the unforeseen byproduct of EIC strategic decisions designed to reduce their engagement in intra-Asian trade. Private traders wove local interactions into a global institution (the EIC) creating the dense structures we associate with globalizing processes on the back of the existing trade infrastructure -- the goods, men, and information who traveled on the sanctioned arcs linking ports.

One of the lessons of network theory has been that social relations and structure matter even where they may be least expected. That is always a fun finding for sociologists. Here we observe something more unusual; social networks also matter where most expected, in unregulated, uncertain situations crossing cultural, social, and political boundaries. We show that for a limited period of time there emerged a unique opportunity for self-interested actors to act; that their actions cumulated into a network structure that transcended them, and ultimately created the context for their own demise. That this context was also the context for the emergence of modern capitalist markets is fitting for it suggests that the global capitalist trade networks now so familiar to us were to some significant extent the product of individual malfeasance.

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Table 1
Cross tabulation of private trade voyages and legitimate voyages over the regional experience of captains, specific to target voyage, 1680 to 1764.

Experience	Legitimate Trade	Private Trade	Total
0	224	79	303
	(28.6%)	(27.4%)	(28.3%)
1	301	66	367
	(38.5%)	(22.9%	(34.3%)
2	178	76	254
	(22.8%)	(26.4%)	(23.7%)
3	65	40	105
	(8.3%)	(13.9%)	(9.8%)
4+	14	27	41
	(1.8%)	(9.4%)	(3.8%)
Total	782	288	1070
	(100%)	(100%)	(100%)

*Pearson chi2(4) = 54.4325 Pr = 0.000

Figure 1. Ports and scaled total tonnage over four-year periods

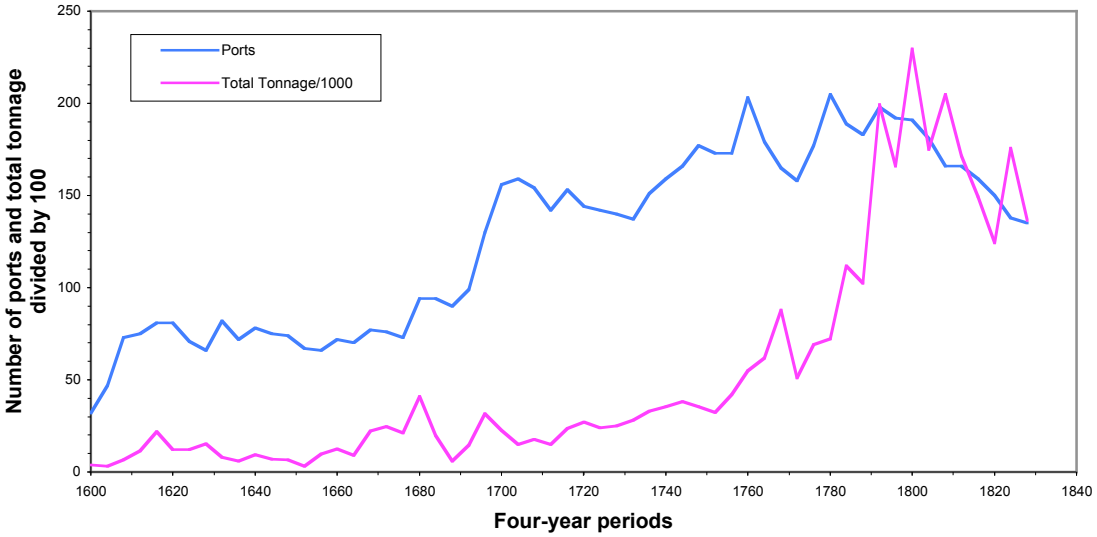
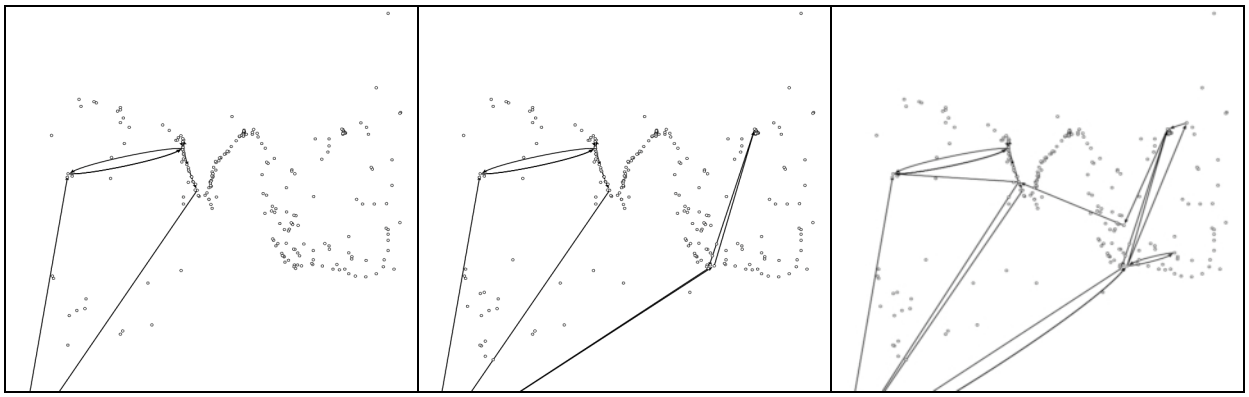


Figure 2A-C. Spatial representations of the voyage of the Prince Augustus, the voyages of the Prince Augustus and the Lyell, and the voyages of the Prince Augustus, the Lyell, and the Princess Amelia, 1720.

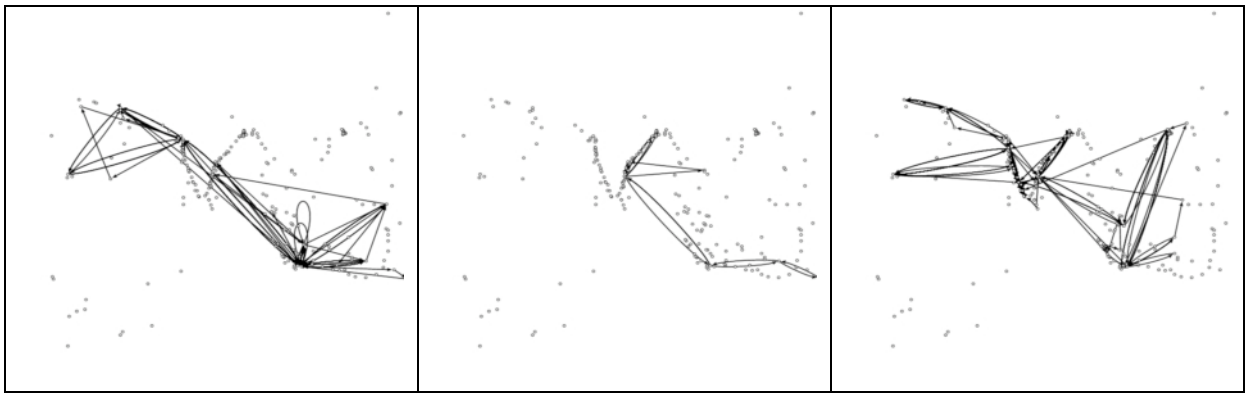


A. The Prince Augustus

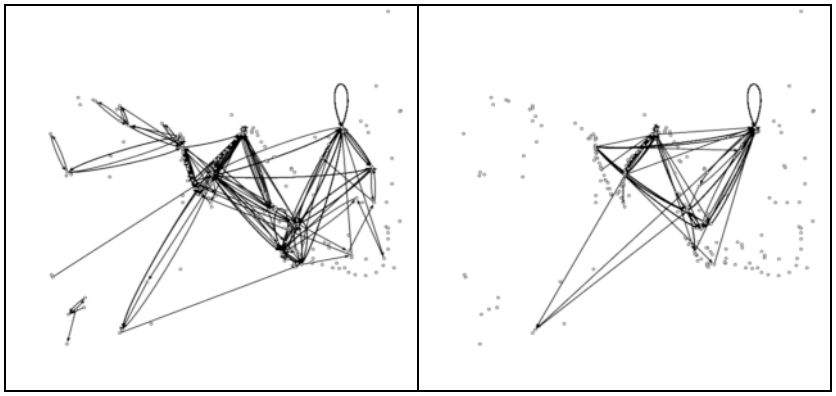
B. The Prince Augustus and the Lyell

C. The Prince Augustus, the Lyell and the Princess Amelia

Figure 3A-E. Development of Eastern trade over geographic regions in snapshots of five four-year periods: 1620, 1680, 1720, 1780, and 1820.



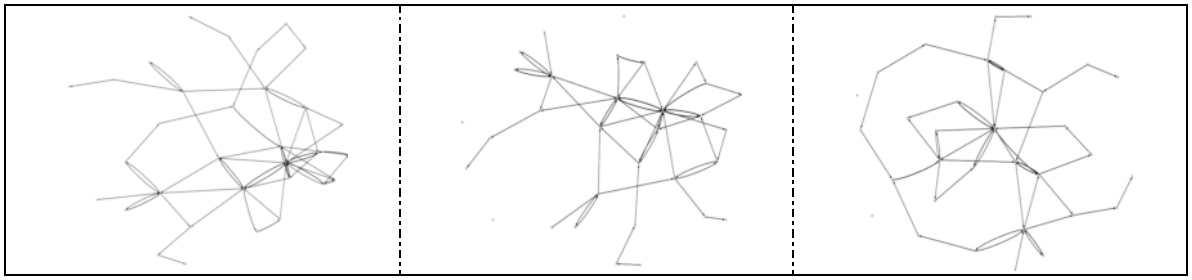
A. 1620 B. 1660 C. 1720



D. 1760 E. 1820

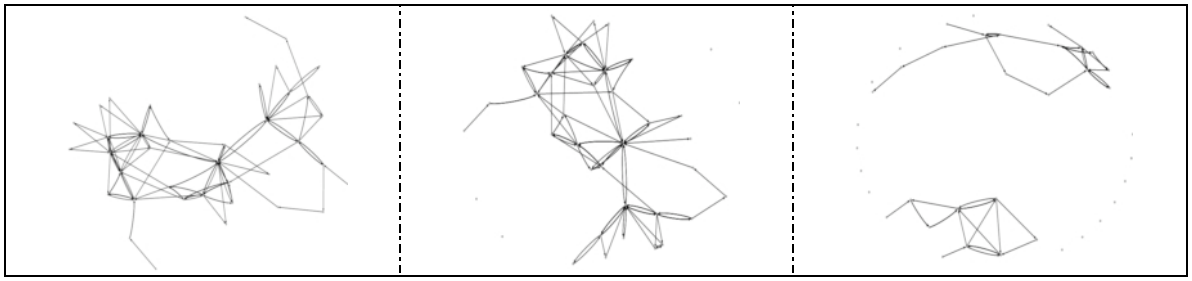
Figure 4, Panels A-E. Network visualizations of the EIC's eastern trade.

Panel A



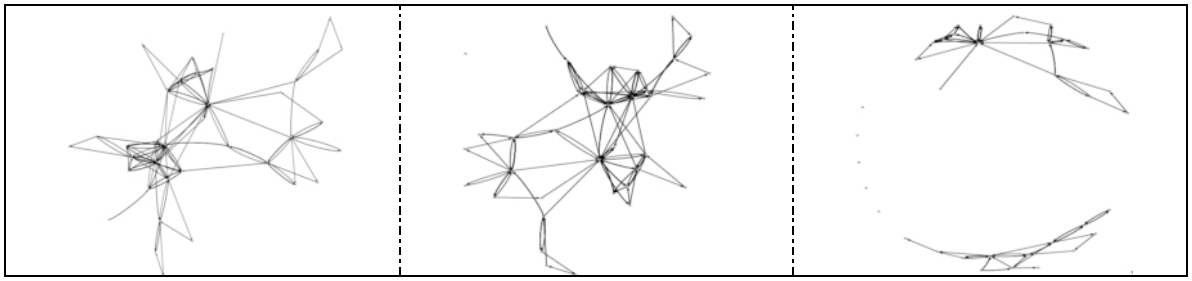
1680 Total trade network | **1680 Matched voyages removed** | **1680 Private trade removed**

Panel B



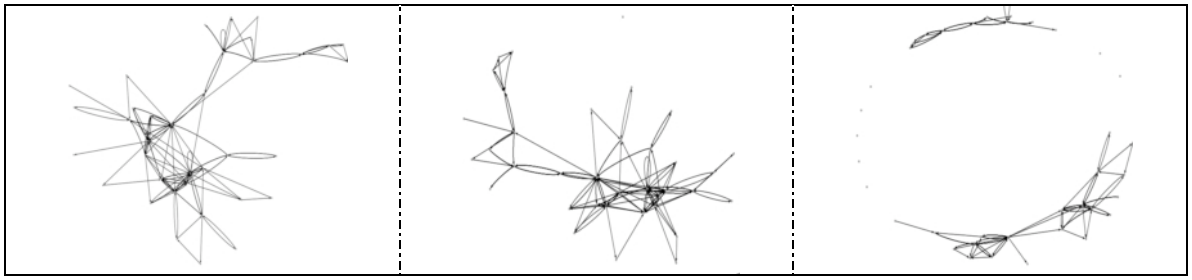
1712 Total trade network | **1712 Matched voyages removed** | **1712 Private trade removed**

Panel C



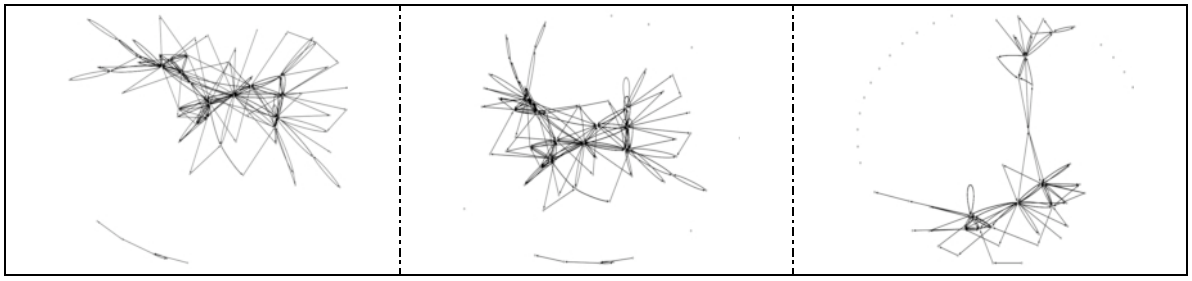
1720 Total trade network | **1720 Matched voyages removed** | **1720 Private trade removed**

Panel D



1728 Total trade network | **1728 Matched voyages removed** | **1728 Private trade removed**

Panel E



1760 Complete trade network | **1760 Matched voyages removed** | **1760 Private trade removed**

Figure 5. Integration levels of total graphs, graphs with private trade removed, and graphs with matched voyages removed over four-year periods from 1680 to 1764

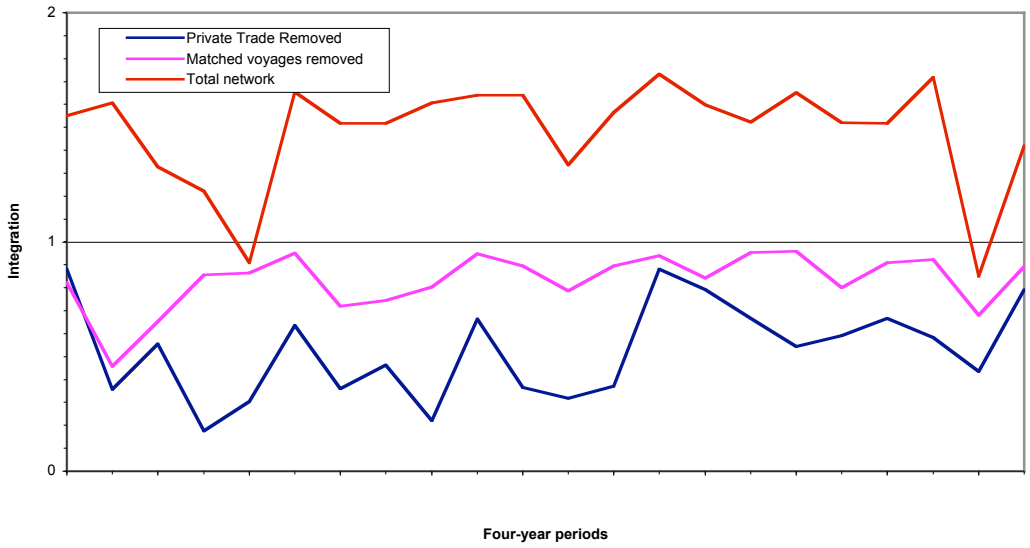
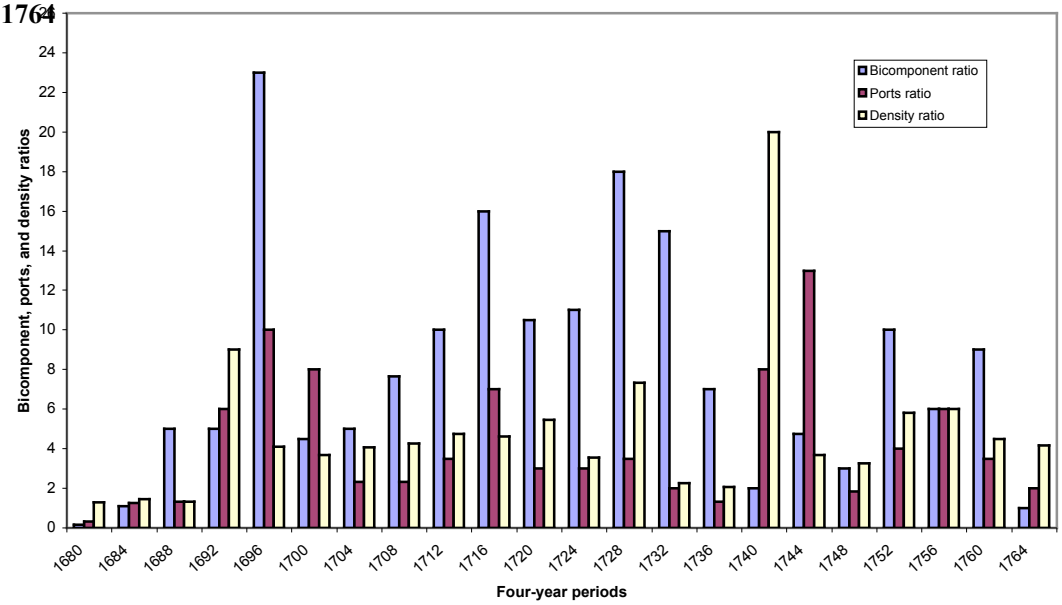


Figure 6: Relative impact of private trading on graph density, the number of ports in trading network, and largest bicomponent size in the East, 1680 to 1764



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