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## **Structural Autonomy, Social Networks, and the Exploration and Exploitation of Knowledge**

**Sampsa Samila**

Brock University

Faculty of Business

sampsa.samila@gmail.com

**Emily Erikson**

emily.erikson@yale.edu

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# **Structural Autonomy, Social Networks, and the Exploration and Exploitation of Knowledge**

## ***Abstract***

*Research on the exploration and exploitation of knowledge suggests that the autonomy of subsidiaries or units encourages innovation. However, that same autonomy potentially discourages the exploitation of innovations through inter-unit communication – suggesting a tradeoff between innovation and communication. This research has often addressed cases in which informal avenues for information between units have to be created by the organization. We examine a situation in which units are already embedded within a network of opportunities to communicate commercial information. We find that units are more likely to communicate information through these available pathways when they have greater autonomy. We conclude that integration and autonomy are not systematically at odds with each other, although previous organizational theory has suggested otherwise.*

## ***1 Introduction***

Organizational theorists have long appreciated the trade off between the exploration of new knowledge and the exploitation of current knowledge (March 1991). Organizations manage this trade-off through the allocation of resources and also through restructuring the organization itself, the latter of which is the focus of this paper. Increasing the autonomy of organizational subunits allows them to explore new ideas and has been linked to innovation. Centralization, on the other hand, integrates subunits, allowing for better internal communication and thus the exploitation of knowledge within the organization (e.g., Egelhoff 1988, Sorenson and Sorensen 2001). New knowledge discovered in one part of the organization can be quickly spread across the organization and put to profitable use.

We argue that although there may well be a trade-off between exploration and exploitation,<sup>1</sup> it is not necessarily linked to decreased communications in decentralized firms. We present evidence that relative to communication, the trade off between autonomy and centralization is not a given. Indeed, we show that the autonomy of subunits and integration can

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<sup>1</sup> The allocation of scarce resources is another explanation for the existence of the exploration-exploitation trade-off.

coexist through decentralized communication, thereby simultaneously encouraging exploration and exploitation.

In order to examine this problem we have used a case in which one firm undergoes significant organizational shifts that altered the functional autonomy of units – and units are embedded within a network of opportunities to communicate with each other when the firm is both decentralized and centralized. The English East India Company, an early-modern overseas trade organization, provides an extremely valuable case with which to evaluate the effect of increased autonomy on the exploitation of knowledge generated within the firm. The company itself went through two different periods, one lasting roughly 180 years and the other lasting roughly 50 years, in which the autonomy of units went from very high, in the first period, to low, in the second period. This variation allows us to examine the relationship between structural autonomy of subunits and both the exploration and exploitation of knowledge within the firm through the discovery and incorporation of new ports into the larger organizational network of trade. In this case, we consider exploration to be traveling to a new or relatively new port and exploitation to be the incorporation of that port into other captains' voyages. In the first case, one individual explores new territory, and in the second, that information is communicated to and exploited by others within the firm.

Unlike today, the passage of information, goods, and capital were consolidated along a small number of available channels in the pre-modern period. Today, multiple information networks, cellular, telephone, email, internet, personal, commercial, overlap and feed into each other. The number of potential channels for communication makes the analysis of network communications difficult to observe (Egelhoff 1982, p. 436, Ghoshal, Korine, Szulanski 1994). In the early modern period, this complexity was reduced. The large commodity-carrying ships

were also the principal conduits in the transmission of information throughout the region. Therefore, the records of the shipping network of the English capture a flow of goods, capital, persons, and information that can be transformed into an analytically tractable network that captures a large proportion of English interactions.<sup>2</sup> Thus, we are also able to observe the decentralized transmission of information between captains while en route in the East Indies.

Our findings suggest that organizational theory should reconsider the trade off between autonomy and centralization. In the case of the East India Company, autonomy was associated with both exploration, more visits to newly discovered ports, and exploitation, more communication about those new ports between captains as well as between captains and principals.

## ***2 Communication and Autonomy***

Since before the publication of March's key formulation of the problem (1991), organizations and theorists have attempted to identify organizational characteristics that encourage an optimal balance between the exploration of new knowledge and the exploitation of existing knowledge. In March's original model, new, or unsocialized, employees enter into an organization bringing new beliefs about the organization and its environment. Improvements in knowledge within the organization come through the gradual and partial assimilation of the beliefs of these new employees. The individuals are able to bring new information to the organization because of their autonomy from the existing organizational code -- where the code is the set of beliefs carried within the organization about itself and its environment. This model suggests that

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<sup>2</sup> By this we mean English-English interactions. Systematic data on Asian and Middle Eastern trading voyages is not available. There were also country voyages made by English traders that are not captured in any extant data.

autonomy -- in this case autonomy from the organizational code -- is central to exploration, which is understood as the process of gaining new information.

The logical dilemma, however, is that organizational learning depends upon individuals adopting the organizational code – effectively losing their autonomy. The code slowly improves through incorporating correct knowledge, but there is no benefit unless individuals within the organization are socialized by the organizational code. The exploitation of knowledge depends upon some significant loss of unit autonomy.

Researchers have indeed found that in many cases there is a trade-off between exploration and exploitation (Holmqvist 2004, Park et al. 2002). The trade-off is not always explicitly tied to the autonomy of units or employees, and March himself argued that part of the dilemma resulted from the allocation of scarce resources to either exploration or exploitation. Deborah Leonard-Barton (1992), for example, shows that although core-capabilities (successful routines for the exploitation of organizational knowledge) produce the capacity for exploration, they also inhibit development of new products by trapping individuals within unsuitable technical and cultural systems established around the existing core-capabilities. And Sorensen and Stuart showed that older firms (with developed core-capabilities) are better at incremental improvements to existing technologies and worse at responding to new market demands through the development of new products (2000). Process-management, a method of increasing control over organizational routines, produces efficiency gains for organizations, but is also associated with decreased innovation (Bennan and Tushman 2002 2003, Henderson et al. 1998, Sterman, Reppenning and Kofman 1997). Sorenson and Sorensen (2001) show that franchises, which have greater autonomy from the firm than centrally operated units, are more likely to innovate than units operating under traditional hierarchical governance structures. However, they are less likely

to produce innovations that will help other units and less likely to communicate these improvements to the rest of the company.

In these cases, the negative association between autonomy and the exploitation of knowledge may arise from the differential allocation of time but there is also a second possibility that decentralization is related to a lack of communication between autonomous or semi-autonomous units.

Contingency theorists and researchers have explicitly hypothesized that successful decentralization must be accompanied by the creation of mechanisms to increase communication between departments (Lawrence and Lorsch 1967, Galbraith and Nathanson 1978, pp. 63-89) -- to compensate for the loss of integration that naturally accompanies decentralization. Effectively this has often meant a decentralization of decision-making coupled with a centralization of communication processes, for example through evaluation and reward systems.

Information processing theory is even clearer about the potential conflict between autonomy and intra-organizational communications. In this case, the generation of new information is the domain of exploration and the transmission of information within the organization is the domain of exploitation. Centralization integrates units and increases information-processing capacity, but necessarily reduces the autonomy of units (Egelhoff 1988). The implication being, of course, that decentralization reduces the ability of firms to exploit knowledge, i.e. to communicate information between units.

Through simulations, David Lazer and Allan Friedman brought network structure to bear specifically upon the problem of exploitation and exploration. By formally modeling information channels within an organization, they were able to show the effect of those structures on the balance between exploration and exploitation (2007). Lazer and Friedman did not directly

address the problem of centralization, although their results do have implications for its role in the exploitation-exploration trade-off.

Lazer and Friedman showed that when solving complex problems, longer-total path length between units produces better long-term results. When only a short distance links all units, the group quickly arrives at a solution, but stops searching for improvements, producing worse long-term outcomes for the whole. The conclusion is that, for complex problems, too much communication between units can unbalance the exploration-exploitation trade-off too far in the direction of exploitation. At first glance, one might find this contradictory to the information-processing perspective outlined above; however centralization, particularly in the extreme hub-and-spoke structure, also radically reduces path length. Centralization thereby increases exploitation at the expense of exploration. Lazer and Friedman did not explicitly come to this conclusion, but understanding the relationship between centralization and path length aligns these results with the expectations of information-processing theory.

However the association between centralization and increased communication has not been strongly supported in empirical research. Ghoshal, Korine, and Szulanski find that centralization has no effect -- positive or negative -- on unit-headquarter communications and little or no effect on inter-unit communications (1994). Since centralization is defined in terms of the decreased autonomy of organizational units, their findings extend to the result that decentralization also has no effect (positive or negative) on communication between units.

Instead Ghoshal, Korine and Szulanski find that networking, defined as inter-unit meetings, teams, and frequent visits to headquarters, improves inter-unit communication as well as communication with headquarters. What strikes us as interesting is that networking, which is a decentralized form of communication, is seen as entirely independent of organizational

decentralization. And in fact, further research in this vein has conceived decentralization and networking as entirely separate processes. Venaik, Midgley, and Devinney (2005) argue that increased unit autonomy (i.e. decentralization) and networking between units constitute two independent paths to improved performance for firms.

Thus, the literature specifically addressing these problems so far has found a negative association between structural autonomy and the exploitation of information, and a positive association between networking and increased communication as well as firm performance. What remains unexplored is a link between increasing autonomy of units and increased networking, i.e. decentralized communication. We believe that the decentralization of control in an organization is very likely to be associated with a decentralization of communication patterns, and that decentralized communications constitutes another path toward the effective exploitation of knowledge within organizations -- and one that is not in conflict with the exploratory benefits of increased unit autonomy

Social networks are an emergent feature of social life -- that is they naturally arise from interactions between individuals. When individuals are in contact with each other, they interact and form relationships; these relationships cumulate into social networks. The question then is not when will social networks form, since they are a regular feature of social life, but when will they be used to transmit information about local innovations that may benefit the firm.<sup>3</sup> Here is where decentralization plays a potentially crucial role. In centralized firms, innovative subsidiaries may be viewed with distrust as potentially opportunistic actors. But in decentralized firms, subsidiaries may use their autonomy to both generate and promote innovations. The greater the prestige of the subsidiary, the more likely that they will be granted a receptive

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<sup>3</sup> Given that subsidiaries must have some means by which they come into contact with one another for social networks to form.



audience and therefore transmit potentially valuable information (Birkinshaw, Hood, Jonsson 1998, Ambos, Andersson, and Birkenshaw 2010).

Decentralization also increases the prestige of subsidiaries, drawing actors from the center to the periphery and thereby increasing the flow of information from subsidiaries. For example, Bartlett and Ghoshal discuss the example of Philips. Philips benefited significantly from a network of informal and decentralized communication between managers that sprang up as a byproduct of considerable subsidiary autonomy. Because they were considered prestigious posts, up-and-coming managers typically spent two-to-four years at a number of different subsidiaries scattered around the world. While proceeding from one subsidiary to the next, managers created informal relationships with their co-workers – over time creating a powerful informal network. Thus autonomy led to decentralized communication, which integrated the larger firm -- to its great benefit. (Bartlett and Ghoshal, p. 126).

Here, we re-examine the link between decentralization and inter-unit communications in the context of units that are already embedded in a network of opportunities to communicate with one another. We hypothesize that if units have come into contact with each other in both centralized and decentralized organizational regimes, structural decentralization will be associated with increased decentralized communication and centralization will be associated with reduced decentralized communication. If this holds true, it indicates that increased autonomy does not necessarily decrease the exploitation of knowledge by reducing communications within the firm.

### ***3 The English East India Company***

The English East India Company was a large trading organization with monopoly privileges in England whose commercial history stretches over 233 years, from 1600 to 1833. Though a monopoly in Britain, in Asia it competed against a small number of similar European companies – the largest rival being the Dutch East India Company (*Vereenigde Oost-Indische Compagnie* or VOC in Dutch) – and numerous Asian merchants, a number of who possessed resources comparable to the European national monopolies. Goods traded by these merchants and companies were numerous. They varied from the exotic, for example, diamonds, rose attar, and elephant tusks, to what we now consider mundane -- pepper, cotton, porcelain, and tea. The Company went to 272 ports within the commercially vibrant world of the East. The ports spanned from the Cape of Good Hope to the northern tip of Japan and exhibited vastly different societal types, from the centralized bureaucratic state of China to the kin-based villages of New Guinea.

European trade in the East was divided into two categories: the inter-continental trade between Europe and Asia and the intra-continental trade confined to Asia. This latter commerce was called the ‘country trade.’ In the first 80 years of its existence, the English Company formally participated in both the intercontinental trade and the ‘country trade.’ However employee malfeasance was endemic and control difficult to establish over the long-distances required by overseas trade. English employees in this first period were known to regularly engage in trade for themselves, while employed by the company. This practice was called the private trade.

In response to internal politics, poor performance, and their failure to effectively regulate employees, the Company passed a series of regulations between 1660 and 1680 that legitimized private trade in the East (Brenner 2001, Furber 1948 1976, Furber & Rocher 1997, Marshall 1976 1993, Watson 1980). A turning point came in 1674, when the Company pulled out of much of the intra-Asian trade and opened trade within Asia to Englishmen, including English Company employees. Captains were given an incentive and opportunity to divert Company ships from company business in order to pursue their own private commercial interests (Adams 1996, Furber & Rocher 1997, Marshall 1993, Anderson, McCormick and Tollison 1983, Erikson & Bearman 2006).<sup>4</sup> For example, English Company officer John Barlow recorded in his journal the *sub rosa* trips his captain made to Goa, the Portuguese stronghold, in order to buy arrack for his own private trade (Barlow 1934). Such events were not unusual.<sup>5</sup> In other words captains had a high-degree of decision-making capacity within their organizational framework. In these periods, of employee malfeasance and legitimate private trade, we consider unit autonomy to have been very high.<sup>6</sup>

This situation persisted into the mid-eighteenth century. Between 1740 and 1760, it became clear that the English Company had become the dominant commercial power in the East, surpassing even their longtime rivals, the Dutch VOC. In England, the board of control of the Company had become increasingly rich and powerful. East India Company stock ownership was considered the best investment in the nation, and the Board of Directors had forged new links to

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<sup>4</sup> Other company employees also participated in the private trade. Factors (company merchants that resided in Asian ports) were particularly important. However, we are focusing on the effect of social networks on the captains' movements.

<sup>5</sup> It may seem unusual that the company would have continued to allow unofficial deviations from official voyages; however principal-agency problems were rife within all early-modern trading companies (Carlos 1992, Hejeebu 2005). Smuggling and corruption were endemic among employees working in life-threatening conditions a continent away from their employers. Companies would either spend considerable effort in unsuccessfully policing private trade or give into allowances. The English Company was resource poor and so took the latter route.

<sup>6</sup> Here, ships are considered units.

the government through its involvement in the creation of public debt (Carruthers 1996). In 1757, the Company became significantly more than a firm. Under the leadership of Robert Clive, English Company forces won what is known as the Battle of Plassey, defeating the Mughal Empire and giving English Company control over a significant area of land for the first time. This shift brought with it a new source of revenue in the form of land and agricultural taxes. The company became a colonial as well as a commercial power.

The increased political power in England and Asia considerably strengthened the hand of the principals within the firm. They began to clamp down on the private trade as part of a larger attempt to centralize operations and reduce the decision-making capacity of captains (Furber & Rocher 1997, Marshall 1993, Chaudhuri 1965 1993). The Board launched new investigations into identifying effective means by which to control overseas operations (Cotton 1949). In 1776 the Honourable Board of Directors passed an act that strictly forbade deviations from the ordered routes and ordered captains that deviated to appear before a joint committee of Private Trade and Shipping to explain their actions (Cartwright 1788?). In this later period, we consider unit autonomy to have been significantly reduced.

#### ***4 Statistical Model***

Throughout the history of the firm, captains faced a similar situation once at sea. As each captain pulled up anchor, unfurled the ship's sails, and drifted into tropical waters, they had several considerations to weigh. They were about to pilot a 1,000 ton wooden ship into uncertain waters with a crew of 100 or more men, half of whom may have been suffering from scurvy, malaria, or a host of other illnesses and parasites that drastically lowered the life expectancy of Europeans in

the East (Cotton 1949).<sup>7</sup> The crew and the captain were interested in making their own fortunes. However, they had to pursue their ambitions within the framework of employment offered by the English Company.<sup>8</sup> The Company would not immediately know if the captain deviated from his route, but they would notice if that deviation caused the ship to arrive in England late. If the Company principals did notice, there was the potential for dismissal. Given this, the captain had to decide where he might find a safe haven and good prospects for trade. It is reasonable to assume that captains were acting on information about viable commercial opportunities at ports. They had three potential sources of information: organizational knowledge, personal experience, and social networks. Our central question is whether the use of social networks within the firm, i.e. decentralized communication, varies with the decentralization of control within the firm.

In order to analyze the effects of social networks, we treat the decision of a captain to travel from one port to another in the East as the unit of analysis. The captain's decision is operationalized in the data as the creation of a directed tie between two ports. A tie occurs in the trade network when a captain travels from one port to another.<sup>9</sup> This tie is the dependent variable.

We began by assuming that when choosing his next port, a captain could in principle travel to any other of the 272 ports visited by EIC in the East. We then used a fixed-effects logit model to estimate how the probability of choosing a particular port deviates from a baseline probability as a function of social networks, formal orders, and personal experience. If having information about a particular port through social networks makes captains more likely than the

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<sup>7</sup> 61% of the men serving within the EIC in the East died while employed (Hejeebu 2005).

<sup>8</sup> Hejeebu also shows that profits from the private trade are likely to have increased with time – as individuals gained more experience and local knowledge (2005), giving employees an larger stake in future employment.

<sup>9</sup> The creation of a tie is, of course, a fundamental issue in network dynamics because the types of ties that are created determine the evolutionary pattern of the network as well as its structure at any given point in time.

baseline expectation that that port will be chosen, we expect that the coefficient for social networks will be positive and statistically significant.

The baseline probability, i.e., the fixed effect, includes components for the directed dyad, season, and time period. Including the directed dyad component controls for such time-invariant factors as the distance between two ports, the popularity of certain routes, as well as prevailing winds and currents which might make the voyage in one direction easier than the other. For many commodities, the source locations are very stable and hence are effectively controlled for as well. The season component, defined as three-month periods, allows for regular variations in weather patterns, primarily monsoons and hurricanes. Finally, the period component allows the baseline to vary over time as the popularity of the ports grows and declines. We use periods of forty years, which roughly corresponds to the pace of change in terms of shifts in the major commodities traded and hence to the factors for which we want to control. Shorter periods run the risk of controlling for exactly the short-term changes in port popularity that arise from formal orders, personal experience, and social networks. To check robustness, we also estimated the models with baseline probabilities based on periods of twenty, sixty, or eighty years and obtained broadly similar results.

It should be noted that if the baseline probability of a particular choice of next port is zero, i.e., if the port is never chosen as the next port from the current port in the current season and period, it drops out of the estimation. This means, for instance, that ports established after 1700 do not appear as viable alternatives in 1640. Ports appear in the choice sets only during time periods in which they are actually visited. We also estimated models where ports entered the choice sets five or ten years prior to first visit or first formal order to visit and exited the choice sets five or ten years after the last visit or last formal order to visit. The results were very

similar, suggesting that the period component of the baseline probability is sufficient to control for the appearance and disappearance of ports.

### ***5 Data and Variables***

The data for this research came from the print volume, *The Catalogue of the East India Company's Ships' Journals and Logs, 1600-1834* (Farrington 1999). This volume integrates information from the journals, logs, ledgers, imprest books, pay books, receipt books, absence books, company papers, and voluminous correspondence of the Company. The initial stage of the project involved the electronic transcription of the information pertaining to all voyages of the EIC, supplemented by the collection of geographic data for the 272 East-Indies ports visited (Milburne 1813, Stevens 1775). The result includes a complete list of the 1,480 ships (4,725 voyages) that were engaged in official EIC trade from 1601 to 1835 and geographic coordinates for all 272 ports. All ships list the trading season in which they were active and 99% percent include the intended destination. The captain of the ship is systematically listed and present in 95% present of the voyages with ports recorded. 85% of the entries for voyages contain a complete set of ports visited.<sup>10</sup>

This list of ports is the key piece of information used for analysis, since it forms the basis of the evolution of the trade network – each trip between ports constitutes the creation of an edge in the network and travel to a new port adds a node. Since this is a crucial piece of evidence, it was important to confirm that the data available in the Farrington volume faithfully recorded the actual passage of the ships. The British Library holds the original ships' logs in the India Office Records Collection. A stratified sample of 107 logs confirmed that the ports listed as destinations

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<sup>10</sup> Of the missing 724 voyages, 188 were terminated due to rotting, wreck, acts of aggression, and other misadventures.

in Farrington (1999) were those recorded in the original logs: dates and ports were correct in all cases.

One may also question whether the purser and captain (the two officers usually responsible for maintaining the log and journal) recorded the actual passage of the ship. As described by the historian Miles Ogborn, the journals...

“were to guarantee to the adventurers in London of the performance of what they had ordered to be done, or at least that decisions made on the voyage did not contradict those orders. Where possible, they were to provide the foundation of succeeding voyages by providing knowledge of winds and shoals, useful ports and places of refreshment, good routes to take, supposedly friendly or treacherous peoples, good commodities and markets, and the extent of Portuguese and Dutch power as well as the orientations of Asian politics. These journals were collated, archived, and used by the Company in increasingly systematic ways in order to provide ‘navigational’ knowledge for subsequent voyages” (2007: 49).

This guarantee raises the possibility that the captains and purser might omit ports from the logs that weren’t consistent with official orders and regulations – in order to hide transgressions from company officials. There is no evidence of such omissions. Instead, Portuguese and Dutch ports, legitimately off limits to EIC traders, are recorded in abundance. The practical reason for this honesty is that the log served as a navigational tool during the course of the voyage. The log tracked weather conditions as well as position. Without an accurate record, the ship would be lost, and therefore at risk -- good reason to keep an accurate record.

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 – or 234 years -- from the granting of the royal charter, December 31, 1600, to the return of the last ship, the *General Palmer*, on March 3, 1835. The data captures both ‘networks,’ patterned interactions between individuals in different ports, and ‘flows,’ the movement of commodities, capital,



people, and information (Castells 1966, Gotham 2006). It is the patterns of interactions between individuals that determine the subsequent ‘flow’ of goods, currency, news, and people.

### *Peer-to-Peer Networks within the Firm*

Historians have also provided anecdotal evidence that informal networks were an important source of information within the EIC: “the official correspondence between the directors and the factories also had as its constant shadow an extensive network of private communications, both within India and between India and London.” (Ogborn 2007: 95). However, they have not provided systematic evidence of their existence or whether their use varied over the life of the firm.

Though ships were often dispersed across Asia, they came into contact with each other regularly at frequent ports-of-call. If informal relationships between employees were used to transfer information, the opportunity to communicate came when English captains and crews shared the same harbor. EIC employees came into close personal contact with each other when sharing a common port. If the port had an English factory, the factory would serve as the living quarters for all Company employees. In most ports, English access to social and residential life was restricted by the local government. The English, as well as most other foreign merchants, were consigned to merchant ghettos, called *nattios*. As a result, these factories became the center of English social life overseas (Cotton 1949), facilitating the collection and transfer of information. Therefore, each captain should have been able to access information about the ports visited by each of the other captains anchored or recently anchored at the same port.

The data systematically reports only arrival dates, so the exact overlap is unknown in most cases. The total number of completed trips over the history of the organization was 14,065.

In 1,012 voyages additional notes in the data recorded the departure date of ships from one or more of the ports visited in the East Indies.<sup>11</sup> Out of a sample of 200 of these voyages, 72 trips had complete information. We used this information to estimate the time it took to travel between ports and the average stay in ports, which became the basis for our calculation of departure times from ports.

If the factories provided a home away from home for the English overseas, residents of the factories should have been able to store information that could then be transferred from ship to ship without direct overlap. However, the information would have to be timely to be useful. We estimated that information stayed in ports for four months after the departure of a ship. The model results are robust to variations of this estimate.<sup>12</sup> A small number of voyages originated in Asia. In these cases we estimated that they gathered in the port four months prior to departure to make preparations.

Using the supplied arrival times and the imputed departure times, we can assess which captains had an opportunity to get information from other captains. If two captains were in a position to communicate information, we assumed that the captains received information about the most recent port the other ship had visited.<sup>13</sup> We coded the variable *SN* as 1 for a dyad if a captain had just received information about the possible destination port and as 0 otherwise.

Since social networks within the firm clearly reflect the communication of information between units, we consider this linked to the exploitation of knowledge.

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<sup>11</sup> Port departure often replaced port arrival information.

<sup>12</sup> There was almost no change in results based on 3 and 5 months storage periods. Additional models available on request from authors.

<sup>13</sup> We also tested the models with the assumption that the captains shared information about all prior ports on the current voyage. The results were very similar, which suggests that timeliness of information was important.

### *Captain's personal travel experience*

Captains also had access to the store of information they had accumulated through their own travels in the East. The disadvantage of personal experience is that it is limited when compared to the information available through social networks and also more likely to be out of date. On the other hand, personal experience may reflect trusting relationships across firm boundaries or a deep cultural knowledge of sites that cannot be transmitted to others.

In either case, personal experience is a potentially crucial source of information for captains that must be disentangled from information transmitted through peer networks. In a trade network such as this, information is not only transmitted through the network, *it traverses the network* as actors move from location to location.<sup>14</sup> The personal experience variable *PE* captures the movement of information as it is carried and accumulated by the individuals that traverse the network. It is recorded in the data as a binary variable: 1 if the destination port is part of a captain's past repertoire from past voyages, 0 otherwise. Since captains rarely return to a port during one voyage (Erikson and Bearman, 2006), we exclude prior ports on the current voyage from personal experience.

### *Formal organizational goals*

The captains were also presented with formal voyage targets, which they may or may not have used to direct the passage of their ships. If they were to abide by the terms of their contract, captains were obligated at some point in their voyage to journey to the destinations indicated by the board of directors.<sup>15</sup>

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<sup>14</sup> This dual movement, transmission and traversing, occurs in many real-world networks, i.e. transportation, migration, and trade networks.

<sup>15</sup> Directions to captains are often listed in the first pages of ships logs and appear scattered through the paperwork associated with each voyage, bound in separate volumes in the India Office Records division of the British Library in London.

These destination ports were systematically recorded in the catalogue of ships' voyages (Farrington 1999). Destinations were occasionally vague. When an area was listed rather than a port, we supplied the site of the major English factory in that region. For example, if Bengal was listed, we supplied Calcutta as the formal destination of the voyage. Our reasoning was that imprecise directions are only possible when general knowledge is high; therefore, vague directions are only given if the most obvious answer is the correct one. If the listed destination was too imprecise, i.e. the East Indies, we did not replace it. We did, however, supplement the recorded destinations with the list of major factories and ports known as intermediate docks for those factories (Surat, Benkulen, Hugli, Vizagapatam, Masulipatam, Diamond Harbour, Saugor, Second Bar, New Anchorage, Whampoa, Penang, Singapore, Johanna, Madras, Bombay, Calcutta). These were the centers of EIC administrative power in the East. Captains pursuing their own trade were unlikely to make undirected stops at these official ports, even when private trade had limited legitimacy during the late-17<sup>th</sup> to early 18<sup>th</sup> centuries. Drawing from a sample of ships' logs, we found that, again, if a destination was uncommon, it was likely to be noted in the first pages of the logs.<sup>16</sup> More common destinations, i.e. *Mumbai* and *Chennai*, could go unnoted although they were part of the official route intended for the ship by the board of directors. We use the variable *FO* to indicate formal orders to travel to a port; 1 is a formal destination, and 0 is not. Since additional information about a formal destination would be beside the point – and captains would be more likely to have information about formal destinations because they were heavily trafficked -- this is an important control. We also consider the strength of formal orders to be linked to the centralization of communication within the firm.

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<sup>16</sup> This is almost certainly the case because exploratory voyages were prestigious appointments.

### *Port Popularity*

Ports varied in popularity, and popularity varied over time, meaning some ports were more popular in some periods than in others. Because we are interested in the exploitation of new knowledge within firms, we were particularly interested in the extent to which social networks brought less popular ports, that is ports that might have otherwise dropped out, into the network. To measure the nature of the ports visited through the different sources of information, we created an additional variable (*p2visits20*) defined as the number of times the target port (port 2 or p2) was visited by any captain from any prior port in the prior twenty years.

### *Periods in the Life of the EIC*

Finally we included two dummy variables to control for the two very distinct historical phases of the EIC. As discussed earlier, a significant change occurred in 1757 when the company won the Battle of Plassey and gained control of Bengal. The Company shifted from a commercial operation to a colonial power, increasingly strong ties with the British state were forged, and private trade regulations were altered. The dummy *privatetrade* captures the years prior to 1757, and the dummy *colonialera* covers the years from 1757 until the end of the firm.

## **6 Results**

### *Social Networks and Exploitation of Knowledge*

First we evaluate the effect of social networks on the trade. In our theoretical framework, social networks are only compelling if they are actually helping the firm to exploit new information. Here the crucial information for the firm is about conditions at different ports.

Figure 1 tracks the relationship between port popularity and source of information over the life of the company. We measure port popularity by the number of visits it received in the prior 20 years and on the Y-axis plot the average popularity of the ports visited in that period. The different graphs look at how the average port popularity varied by the source of information used in the captain's decision to visit that port. For instance, the formal order graph plots, for each period, the average popularity of the ports that were visited because the captain was formally ordered to go to that particular port. If decentralization creates a context in which captains are able to pass along new local information, i.e. exploit new exploratory information, than they should steer captains to less-traveled ports when the firm is decentralized, but not when centralization takes place. Therefore, we hypothesize that *1. Social networks guide captains to less-popular ports when the firm is decentralized. And 2. Social networks do not guide captains to less-popular ports when the firm is centralized.*

The results in Figure 1 bear this hypothesis out. Formal orders from the principals consistently steered the trade to ports with above-average popularity, measured as the number of visits to that port in the prior twenty years. Social networks on the other hand directed trade to less-well served ports, with the exception of the last period of the company's life. This period corresponds to the colonial era, which was also the period of highest centralization. Thus social networks seemed to have had an expansionary effect on trade in periods with high unit-autonomy, i.e. decentralization.

If social networks expanded trade by including less popular ports, we should also see an impact on the overall length of voyages. Deviations from established routes that expanded trade should be reflected in longer voyages. In Table 1, we investigate the effect of the different sources of information at the level of the voyage rather than port-to-port trip. The dependent

variable here is the length of the voyage in terms of the number of ports visited in the East Indies.<sup>17</sup> The independent variables count how many times each source of information was used during a voyage. If social networks are introducing new information to captains, voyages should have been extended in order to act on that new information by traveling to ports that would not otherwise have been included in the trade. Therefore we hypothesize that *3. Use of social networks by a captain extends voyage duration.*

In Model 1, the effect of social networks is .832. This coefficient is most easily interpreted to mean that the majority of times (over 80%) when social networks were used to gather information, ships were effectively diverted from their routes in order to add an additional port to their voyage, thus increasing the overall voyage length. Again, it is unsurprising that formal orders to additional ports would increase voyage length, but notable that personal experience has a reduced effect. In Model 2, we control for the route the captains were ordered to take by adding dummy variables for each of the formal order ports. The effect of social networks and personal experience is reduced only marginally. In Models 3 and 4, we add further controls, dummies for forty-year periods<sup>18</sup> and a dummy for each captain. Once again, the impact on the results is marginal.

Models 1 through 4, however, fail to specially address cases in which different types of information were passed along about the same ports, for example, when both formal orders and social networks carried the same information. We expect that social networks were not decisive when paired with formal orders to travel to the same port. Hence, in Models 5 through 8 of Table 1, we repeat the regressions of Models 1 through 4 while breaking the ties for the information sources so that if formal order and either personal experience or social networks were pointing to

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<sup>17</sup> Since our model only considers the choices of ports east of the Cape of Good Hope, this regression effectively requires at least two port visits in that area; hence the lower number of cases.

<sup>18</sup> Since these periods cover the entire life of the company, the constant is not included in the regressions.

the same port, we count it only as a use of formal orders. Likewise, we break a tie between personal experience and social networks in the favor of personal experience. Hence, in these models, social networks are only counted as influential when they were the only source of information about the port visited. The results are again robust across the range of controls and now show that social networks, when they were the decisive factor, on average added more than one port to the total length of the voyage.

Overall, these results demonstrate, first, that social networks were a factor not only in captains' choosing where to travel, but also whether to add additional ports to their voyages. When social networks were used, they tended to add less popular ports to their voyage, thus broadening the organizations knowledge base.

Finally, we can examine whether social networks were used to introduce ports to the regular trade of the EIC and once introduced, whether social networks also sustained trade with those ports. In this case we want to consider whether initial visits to popular ports tended to be directed by social networks, personal experience, or formal orders.<sup>19</sup> We can also consider whether the last voyage to a popular port was based on social network information – indicating that networks extended trade with that port. If social networks are used to transmit (i.e. exploit) new, local information between units within the firm, we should see that they guide captains to initial visits with popular ports. If social networks assisted in the exploitation of knowledge within the firm, we should also see that they kept information about ports circulating within the firm longer than either personal experience or formal orders. Therefore, we hypothesize that 4. *Social networks led captains to new ports that were entering the network*, and 5. *Social networks led captains to visit ports that would otherwise have fallen out of the company trade.*

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<sup>19</sup> Although social networks require a previous voyage to a port, some voyages – particularly initial voyages – are not associated with any of the information types we were able to capture. It is most likely that these were based on information gathered through social networks outside of the firm.



Figures 2 and 3 present the results of these analyses. These figures are limited to reporting information about the 85 ports that were visited at least ten times. In Figure 2, we look at which of the sources of information was active first in the trading life of the port. We mark a port as a formal order port if it was visited due to formal orders before it was visited due to personal experience and social networks. Similarly for personal experience and social networks. Again, if formal order and social networks or personal experience all serve as sources of information about a port, we consider formal orders the most relevant and mark the port as a formal order port. The result is striking: 45% of the most active ports had social networks as the first information diffusion mechanism. In figure 6, we use the same approach to examine which of the sources of information were active last in the trading life of the ports, effectively sustaining trade. The result is very similar: social networks sustained trade to 47% of the most popular ports beyond the time when the other mechanisms were active. In fact, of the ports that became formal order ports, that is ports to which captains were formally ordered to visit, 21% were social network ports first – that is information about these ports was diffused via social networks prior to their incorporation into the formal structure of EIC trade.

These results indicate that social networks in the English East India Company both expanded and sustained the trade network. They were a successful mechanism for the exploitation of new knowledge within the firm.

#### *Results: Decentralization and Network Activity*

The remaining question is whether social networks were associated with increased unit-autonomy or the centralization of the firm. Table 2 presents the results from Models 1, 2, and 3.

Model 1 is the most basic. Here we are simply evaluating whether social networks were used in the English trade. The previous section showed that networks transmitted valuable information inside the firm, but we have not yet tested whether social networks were consistently used to transmit information about ports within the firm. We hypothesize that 6. *Social networks were used to transmit information about ports between units.*

Despite controls for the popularity of the choice of port, the time period, the season, formal orders, and personal experience, social networks are highly significant. That is to say that if a captain had access to information about a port through social networks, they were more likely to travel to that port.<sup>20</sup>

In Model 2, we again consider whether social networks are associated with trade to more or less popular points – i.e. are social networks a conduit for transmitting information gained through exploratory voyages. This analysis is a second check on the important hypothesis that networks actually transmit new information. Here we use the variable *p2visits20* to capture port popularity. The coefficient for port popularity interacted with both social networks is negative and significant. Indeed, the estimated likelihood of visiting a port due to information carried by social networks is almost four times as large for a port with just one visitor in the last twenty years than for an average port. (Recall that there must be at least one other recent visit in order to transmit information via a social network.) This result suggests that social networks tended to be most influential when bringing information about less popular ports -- when communicating new information.

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<sup>20</sup> The differences in effect sizes, however, are notable. While social networks increase the likelihood of choosing a particular port by 12%, formal orders make the choice over nine times more likely than otherwise. The large effect of formal orders is to be expected as captains had to go to the ports they were ordered to if they wished to remain employed.

In Model 3, we consider how the shift from a commercial to colonial organization in 1757 affected the sources of information used by captains. Since we know now that networks do transmit valuable information within the firm in this case, the remaining question is whether they are more or less active in decentralized and centralized organizational regimes. We hypothesize that *7. Social networks will be more active when the firm is decentralized and less active when the firm is centralized.*

Interestingly, personal experience had a roughly consistent effect across these two periods – showing that despite the change in organizational regimes, captains maintained some ability to direct their voyages. There is a slight increase in the point estimates of the coefficients, but they are not statistically different from each other. The effect of social networks, on the other hand, disappears completely during the colonial era, and the coefficients for the two periods are statistically different at the 5% level. Thus there is a clear break with the earlier period. Decentralized communications disappeared with the beginning of the colonial era and its concomitant centralization of control within the firm.

Putting these results together gives us a more complete picture. Peer-to-peer communication within the organization was only active during the period of autonomy and lead captains to exploit local sources of information to visit less popular ports. Over time, many ports visited early on through peer information became central to the trade network. The peer information also sustained trade longer to these ports.

## ***7 Discussion***

In the English East India Company, captains used social networks to find information about trade opportunities and their use of social networks had direct consequences for the pattern by which

the firm pursued trade. When social networks were active they expanded the portfolio of ports actively engaged in trade. The captains effectively used their autonomy to explore local opportunities, straying off established paths – but that autonomy also encouraged captains to transmit the information they gained on exploratory voyages to others in the firm. During the last decades of the organization’s life, control was increasingly centralized, and social networks became ineffective. They stopped leading captains to less popular ports, and they had no significant impact on influencing captains’ decision to travel to specific ports. Our conclusion is that in the English East India Company social networks were an effective mechanism for the exploitation of knowledge gathered within the firm, and they are associated with decentralization conceived as high unit-autonomy.

One could argue that centralization reduced the captains’ opportunities to travel to different ports, thereby destroying the opportunity to act on social networks, but not necessarily the networks themselves. However, personal experience had a relatively stable impact on captain’s decision across both time periods, indicating that opportunities to act remained within the scope of the captains’ abilities. Even in periods of high organizational control, it was difficult to undermine the unique authority of the captain at sea on his own ship. However, it is clear that centralization depressed communication between captains – thus destroying or diminishing the network of decentralized information that had shuttled innovative information about local markets into the hands of others in the firm. The delegitimation of the captain’s explorations did not keep them from pursuing private investments, but it did keep them from communicating the information they received with others as well as with the firm’s headquarters. Such a result is consistent with Bartlett and Ghoshal’s research on the link between operational autonomy and commitment and collaboration within firms (Bartlett and Ghoshal, pp.115-134).

This case is however strongly defined by the fact that captains were in contact and therefore communication with each other whether the firm was decentralized or centralized. In contexts in which units or subsidiaries are isolated from each other, and are entirely dependent upon headquarters to install communication channels between units, centralization may, at least initially, be the only option for increasing integration. In fact we believe that it is likely that centralization and integration were theoretically conflated in the exploration and exploitation literature because research was conducted in contexts where units were relatively isolated from one another.

The large-scale decentralization of firms through the creation of multi-national structures took place in the context of global expansion. The decentralization of control that accompanied the creation of multi-divisional, multi-national organizational forms may have contributed to a lack of effective communication between units; however it should also be considered that geographic and organizational expansion in and of themselves are likely to have a significantly negative effect on intra-firm communications. Therefore it is very possible that many of the integration problems associated with decentralization should be more properly assigned to problems caused by expansion. The best way to remedy this blind spot is through further research on decentralization's effect on integration and communication patterns in the context of organizational or geographic consolidation. We hope to encourage research in this vein.

If decentralization has been linked to expansion, it is also true that in many other cases, centralization has been implicitly tied to the idea of integration. Of course, centralization is simply one means to achieve integration and other decentralized patterns, for example generalized exchange (Bearman 1997), may in fact be more effective at creating group cohesion.

In this case, we join a large community of scholars that have identified numerous mechanisms beyond centralization that serve an integrative function (for example, Galbraith 1973, Bartlett and Ghoshal 1989).

Generally, the result is positive in that one of the great frustrations for business has been the trade-off between exploration and exploitation. Although decentralized communications will not be able to address the allocation of scarce resources in either direction, decentralization itself is not necessarily associated with decreases in communication. In fact, given the opportunity to communicate, the opposite is true. Decentralization should encourage both innovation and the communication of those innovations through a peer-to-peer network. These results imply that firms that overlaid upon existing social networks or that are able to generate such social networks internally (Gulath and Puranam 2009), should have a competitive advantage that inheres in their ambidexterity, in this case, the ability to encourage innovation through decentralization and continue to exploit those innovations through decentralized communications. Encouraging the use of decentralized communication technologies (such as email) rather than central knowledge repositories may help to facilitate this process (Kane and Alavi 2007).

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Table 1: Effect of Information Sources on Voyage Length

| Dependent Variable | (1)<br># of<br>Ports in<br>Voyage | (2)<br># of<br>Ports in<br>Voyage | (3)<br># of<br>Ports in<br>Voyage | (4)<br># of<br>Ports in<br>Voyage | (5)<br># of<br>Ports in<br>Voyage | (6)<br># of<br>Ports in<br>Voyage | (7)<br># of<br>Ports in<br>Voyage | (8)<br># of<br>Ports in<br>Voyage |
|--------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| fo_cnt             | 1.439***<br>(19.47)               | 1.501***<br>(28.78)               | 1.446***<br>(27.00)               | 1.513***<br>(15.00)               | 1.621***<br>(21.87)               | 1.697***<br>(35.69)               | 1.649***<br>(33.80)               | 1.721***<br>(18.23)               |
| pe_cnt             | 0.352***<br>(11.02)               | 0.328***<br>(10.18)               | 0.350***<br>(10.89)               | 0.293***<br>(5.36)                |                                   |                                   |                                   |                                   |
| sn_cnt             | 0.850***<br>(14.23)               | 0.780***<br>(14.24)               | 0.769***<br>(14.25)               | 0.752***<br>(7.69)                |                                   |                                   |                                   |                                   |
| pe_no_fo_cnt       |                                   |                                   |                                   |                                   | 0.796***<br>(20.75)               | 0.762***<br>(20.24)               | 0.784***<br>(20.64)               | 0.708***<br>(10.51)               |
| sn_no_fo_pe_cnt    |                                   |                                   |                                   |                                   | 1.341***<br>(18.12)               | 1.255***<br>(18.42)               | 1.234***<br>(18.36)               | 1.204***<br>(9.92)                |
| fo-port dummies    | No                                | Yes                               | Yes                               | Yes                               | No                                | Yes                               | Yes                               | Yes                               |
| Period dummies     | No                                | No                                | Yes                               | Yes                               | No                                | No                                | Yes                               | Yes                               |
| Captain dummies    | No                                | No                                | No                                | Yes                               | No                                | No                                | No                                | Yes                               |
| R <sup>2</sup>     | 0.658                             | 0.674                             | 0.684                             | 0.851                             | 0.699                             | 0.716                             | 0.724                             | 0.870                             |
| N                  | 3535                              | 3535                              | 3535                              | 3535                              | 3535                              | 3535                              | 3535                              | 3535                              |

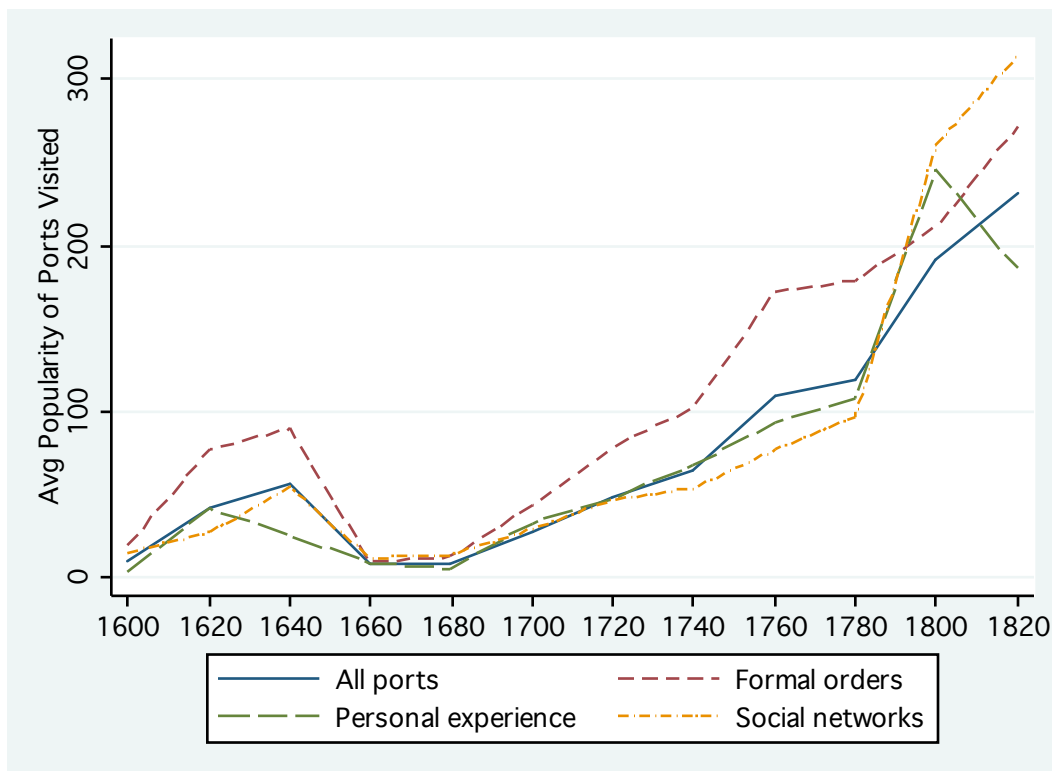
Robust t-statistics in parentheses, disturbance clustered on captains. Constant included, but not displayed. Dummy variables included as indicated but not displayed. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 2: Effect of Information Sources on Choice of Port

| Dependent Variable | (1)<br>Choice of Port | (2)<br>Choice of Port  | (3)<br>Choice of Port |
|--------------------|-----------------------|------------------------|-----------------------|
| p2visits20         | 0.00421***<br>(4.02)  | 0.00557***<br>(4.87)   | 0.00426***<br>(4.10)  |
| fo                 | 2.266***<br>(17.82)   | 2.516***<br>(15.83)    | 2.263***<br>(17.77)   |
| pe                 | 0.278**<br>(5.33)     | 0.480***<br>(6.48)     |                       |
| sn                 | 0.114**<br>(1.99)     | 0.355***<br>(4.36)     |                       |
| fo x p2visits20    |                       | -0.00200<br>(-1.54)    |                       |
| pe x p2visits20    |                       | -0.00149***<br>(-3.35) |                       |
| sn x p2visits20    |                       | -0.00246***<br>(-3.33) |                       |
| pe x privatetrade  |                       |                        | 0.223***<br>(3.36)    |
| pe x colonialera   |                       |                        | 0.301***<br>(4.50)    |
| sn x privatetrade  |                       |                        | 0.264***<br>(3.70)    |
| sn x colonialera   |                       |                        | 0.00319<br>(0.04)     |
| N                  | 127959                | 127959                 | 127959                |

t-statistics in parentheses, fixed-effects logit estimates using directed-dyad-season-period fixed effects, standard errors robust to clustering on the fixed effects. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Figure 1: Average popularity of ports by source of information



*Note: Port popularity is the count of visits to the port in the prior 20 years. Past captain experience and social networks here excludes ports that were also formal orders and social networks excludes ports that were also personal experience.*

Figure 2: Proportion of Popular Ports by Method of First Information Diffusion

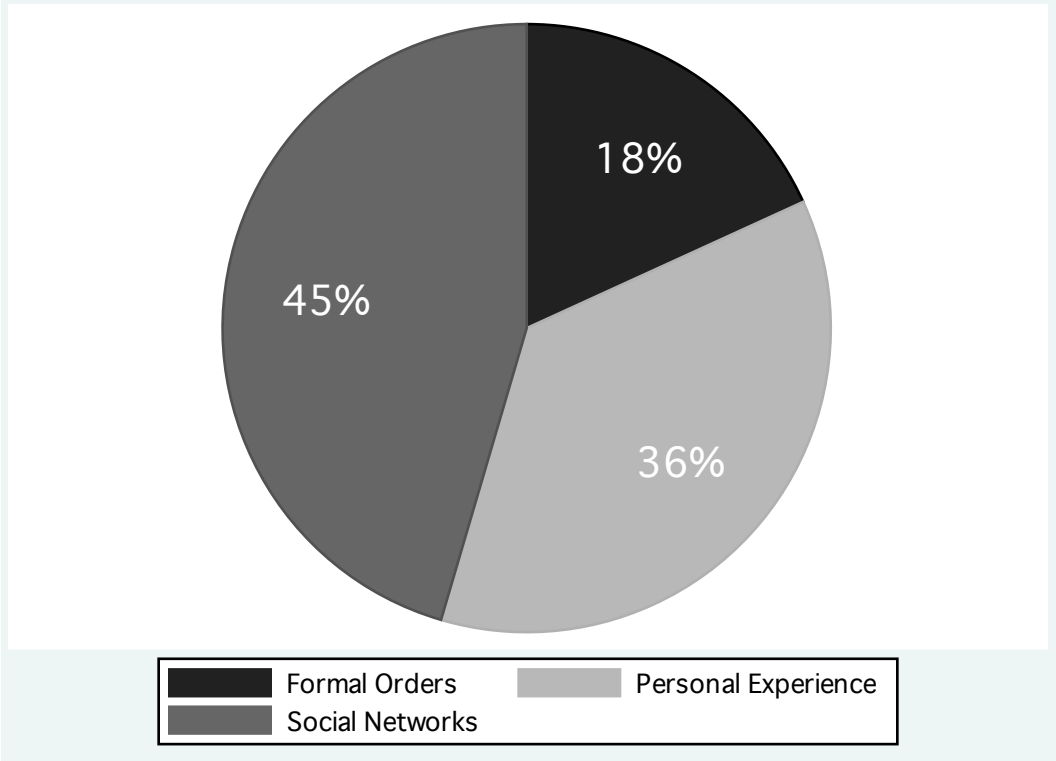


Figure 3: Proportion of Popular Ports by Method of Last Information Diffusion

