

# *A Social Network for Trade and Inventories of Stock during the South Sea Bubble*

by

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## **Abstract**

A social network of stock trading is defined for the notorious South Sea Bubble. Complete market trade in East India Company and Bank of England shares is described in a flow network. Intermediation is treated as a form of network centrality, which can be analysed using measures of pass-through, inventories and immediacy. New features of the South Sea Bubble are documented: i) the crisis suffered by goldsmith bankers may have pre-dated the Bubble; ii) yet the depth and immediacy of intermediation was maintained throughout the Bubble; iii) a gradual trend towards dis-intermediation occurred after the Bubble and iv) there was a switch from intermediation based upon brokerage to intermediation based upon dealership.

## **Keywords**

weighted multidigraph; flow network; financial intermediation; brokerage

## 1. Introduction

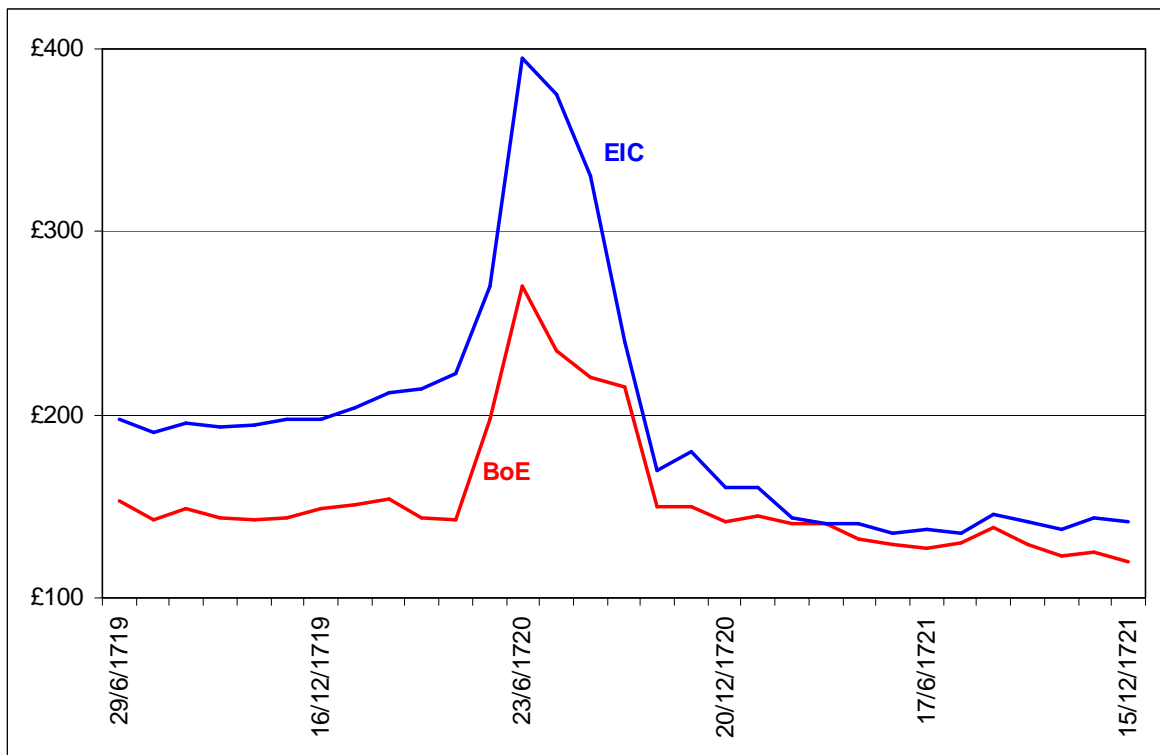
If an investor today wished to buy a share in a prominently traded stock of a public joint-stock corporation, how likely is it that he or she would know, or even have to know, who was the previous owner of the share? The answer is that there is almost no likelihood that buyers would have or would require such knowledge in the impersonal and highly intermediated financial markets of today. Yet in early 18<sup>th</sup>-century Britain trade in shares of even the most important firms could easily be carried out face-to-face between buyer and seller. Historians have described how Britain developed secondary trade in the markets for shares in which investors interacted directly with financial intermediaries and other investors, largely in the City of London, and were much more likely than today to personally know each other and to deal directly with each other (Dickson, 1967; Neal, 1990; Carlos and Neal, 2006, 2008; Carruthers, 1994; Murphy, 2009; Neal and Quinn, 2001). London had even started to differentiate itself from the financial systems of the Low Countries in such ways that it was attracting overseas investors who could also personally interact with British investors and intermediaries in the City (Carlos and Neal, 2011). Face-to-face stock market trading remained feasible throughout the 18<sup>th</sup> century and indeed one of the best-selling financial how-to books of the century (Mortimer, 1761) was published in more than a dozen editions and gave detailed instructions to investors about how to avoid middlemen and how to seek out buyers and sellers directly. Face-to-face trade in British stock markets was common far into the 19<sup>th</sup> century as well. This happened because British joint-stock company promotions were largely devoted towards the building of regional infrastructure projects. A new canal or a railway company would have a few dozen to a few hundred shareholders who were almost all prominent members of the local commercial classes or gentry. Trade in such companies' shares

was often confined mostly to the local populace and the trade in those shares was recorded in the same ways and in the same kinds of stock ledgers that were used in the early 18<sup>th</sup> century (Ward, 1974; Reed, 1975).

As different as early stock markets of Britain were from modern stock markets, they still managed to produce financial crises that resonate today. The South Sea Bubble remains today unarguably the most notorious of the historical financial bubble episodes (Garber, 2000). The Bubble refers to the events in the year 1720 associated with a scheme to convert much of the British national debt into equity shares of the South Sea Company (Scott, 1910; Dickson, 1967; Carswell, 1993; Neal, 1990). There was an attendant stock market boom and crash that took place in a very short time - in about the six months between April and October 1720. The stock market events that affected South Sea share values affected the value of a wide range of stocks, Bank of England and East India Company shares included (Fig. 1). But the South Sea Bubble is very remote in time and there is very little in the way of data that are of a good standard so as to be useful to a financial economist who wishes to study the Bubble. One purpose of this paper is to show how a description of stock trading during the South Sea Bubble as a time-series of network datasets produces clues as to how the financial economist might want to model the asset bubble of 1720.

It is natural to think of markets as network graphs since markets are manifestly describable in terms of trade flows (directed and weighted edges) that connect buyers and sellers (the nodes or vertices). Yet as manifestations of market phenomena network data can be easily confused with a structural description of the market itself. In this paper our interest is to construct new measures on market network data so that we can better ask questions that economic theory can later address. In trying to understand an actual market phenomenon such as the South Sea Bubble our interest

will focus upon questions about financial intermediation. There are three motives for doing this: i) the existing South Sea Bubble literature itself has been concerned with the actions of financial intermediaries, particularly London bankers, during the Bubble; ii) the pure economic theory of market crashes has an element in it that considers the possible ways in which financial intermediary behaviour can cause or prevent crashes and iii) intermediation itself is intrinsically a network centrality concept and new network measures of such centrality could be of general interest to social network analysts. We now address these three motives in a little more detail.



**Fig. 1.** End-of-month share values for Bank of England (BoE) and East India Company (EIC) stocks (Freke, 1719-21).

i) Shortly before 1720, the elaborate system of banking, tax collection and company promotion that was created in France by John Law (the so-called Law System or Mississippi System) started to come apart (Velde, 2009). With the collapse of equity values in France there ensued what historians have identified as a credit

crisis that spread across northern Europe, particularly towards Amsterdam and London. (Dickson, 1967; Neal, 1990). It has been a puzzle, to Neal (1990, pp. 104-5) in particular, as to how the stock market boom in England in the summer of 1720 could have commenced simultaneously with an already unfolding European credit crisis. Credit suppliers in London were famously well connected with corresponding suppliers in Amsterdam, so it would be surprising if a general European credit crisis was not being felt in London. Can we find evidences of reactions to a credit crisis amongst intermediaries whom we identify in our data?

ii) There is an element of the financial theory literature on market crashes that emphasises the role played by financial intermediaries. The seminal work by Grossman and Miller (1988) has been followed by more extensive theorisation by Huang and Wang (2009) and Brunnermeier and Pedersen (2009) and empirical investigation by Comerton-Forde et. al. (2010). The purport of these authors' models is that financial intermediaries are persons who stand between order imbalances – supplies of financial securities on one side that are unequal to the demand for financial securities on the other side of the intermediary. The intermediary can stand ready to overcome order imbalances subject to some costs. Order imbalances can be met from inventories, but there are special costs to being a dealer in inventories. The greatest of these costs are the risks of unfavourable returns on the inventories during the period they are being held. Intermediaries will also need personal capital or will have to borrow in order to fund their investments. Inventories of stock can act as collateral for such borrowing, but the lower is their quality as collateral, the larger inventories will have to become to serve as collateral for a given amount of borrowing. Larger inventories may be a response to speculative losses (losses to personal capital) and/or a lowering in the quality of inventories themselves because

stocks have lost some of their liquidity. On the other hand, before the appearance of the specialist market-maker of today, the possession of inventories might also have been a way of signalling to the markets that a speculator stood ready to buy and sell and have been a factor in reducing his search costs for customers.<sup>1</sup> In equilibrium, strong financing for speculators, inventories with high collateral values and low customer-search costs will tend to produce intermediaries who can operate with small inventories relative to the flows they service. Otherwise with weak financing for speculators, low-quality inventories and high customer-search costs, we would expect to find that intermediaries will have to have large inventories relative to the flows they service. Can we extract practical measures of intermediation from our data that would be recognised as being analytically useful in theories such as we find in the financial economics literature?

iii) Every newly conceived flow-network data structure requires new definitions of network centrality (Borgatti, 2005). A study of intermediation on a network similarly demands the development of new centrality measures. Intermediaries must stand between buyers and sellers so, in a network sense, they must therefore be central and we must identify measures for the volume and density of flows that are most likely to be associated with intermediation. These are measures

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<sup>1</sup> The information networks described by Dickson (1967), Neal (1990) and Murphy (2009) used all types of signals that directed investors to other traders in stock. Coffee houses, for example, became specialised as meeting places for trade in different company stocks. Certain goldsmith banking firms were declared to be official bank for firms. The three partners in the Swordblade Bank were the most famous examples of such persons specially favoured by the South Sea Company. A similar position was held by the four persons who were the major partners in Childs Bank via-a-vis the East India Company, as will be discussed in Section 5. The 18<sup>th</sup>-century system of transfers itself required buyers and sellers to be physically present at company offices to register transactions, where their identities as active traders and holders of inventories would become known to at least a number of clerks and corporate officers. Sworn brokers were publically sworn and officially listed to do brokerage and dealing business in the City of London. See further discussion in fn. 8.

based upon the concept of what we call pass-through. Because inventories are, by definition, the previous accumulations of flows that come to the inventory holder, time also has to become a factor in our analysis. The speed with which sales flow from nodes (immediacy) is a fundamental feature of intermediation that has been of interest to the economic theorists whose work we have previously discussed. Pass-through, inventories and immediacy together allow us to classify network nodes as being more or less central to intermediation. To the analyst with a more general interest in social networks, it should also be clear that our style of analyses should be extendable to other forms of social exchange on networks. Political patronage is an obvious example in which political patrons may receive and dispense favours and may even manage inventories of favours.

At the centre of this paper is the definition of a flow network for stock trading in which the importance of trading nodes is related to the frequency, size and speed of trade and accumulated stock inventories (Section 3). We apply this flow-network data structure to data that are described in Section 2. In Section 4 we describe the global and local characteristics of trading networks, especially with regard to intermediation behaviours during the South Sea Bubble. In Section 5 is described the unenviable fate of the social class that historians have most closely associated with intermediation in 1720, the goldsmith bankers and brokers. Finally, in Section 6 is analysed the dynamic behaviours of markets in 1720 with regard to the locations of inventories and the speed (immediacy) with which they moved.

## **2. Data**

Our data consist of all trade in shares for the East India Company (EIC) and the Bank of England (BoE) in the years 1719-21. The BoE data were collected and

have been described extensively by Carlos and Neal (2006). To their data we have joined our own collection of trade in EIC shares. To carry out a transfer of a share, both buyer and seller (or their representatives) would have to present themselves to the companies' clerks at designated times and on designated days when the companies' books were said to be 'open'. At that time both buyer and seller would have to attest to a transfer that they have agreed and would have to place their signatures to a legal deed of transfer. Deeds of transfer were collected into books that the companies usually called stock journals. In the pages of the stock ledgers, every shareholder would have an account arranged in two columns – a credit column in which stock purchases and sellers were recorded and a debit column in which stock sales and buyers were recorded. These sources did not record stock trade in actual value terms, but recorded only the number of shares passing between stock account owners.<sup>2</sup> The ownership data do not show the extent to which stocks were used as security in other financial contracts, such as forward loan or forward foreign exchange agreements (Neal and Quinn, 2001). There may have been an unobservable network of indirect ownership and trade in shares that is not reflected in our data since some of the ownership that appears in the ledgers may represent ownership in undeclared trust for other persons. Dickson (1967, pp. 251-3), however, considered these problems in his analysis of early 18<sup>th</sup>-Century ownership records for British government annuities

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<sup>2</sup> A transfer can be measured in units of either the nominal value or the market value of shares transferred. In 18<sup>th</sup>-Century Britain it was usual to refer to shares in units of £100-nominal stock. This means that when the total equity ownership in a company was defined (by statute or corporate charter) as a fixed amount, say £1 million for example, the equity ownership could be said to be in the form of 10,000 £100-nominal shares. Such shares would not exist in the form of share certificates, but would nevertheless be the units in which transfers were commonly recorded in companies' stock ledgers. The market transfer values of nominal shares could be vastly different from their stated, nominal size. Such was typically the case during the South Sea Bubble, as depicted in Fig. 1, when EIC share transfer values reached nearly £400 per £100-nominal share.



and concluded that ownership ledgers were probably quite accurate reflections of true ownership. Murphy (2009) concluded that Dickson's analysis was equally applicable to stock ledgers. Indirect (or deliberately disguised) ownership and trade in shares would have had to proceed in a very hostile legal setting. English common and civil law, when applied to disputed ownership of securities, almost always relied on a valid deed of transfer as the ultimate proof of ownership. Contracts in which actions were promised with financial securities that were not in the actual ownership of a contractor were often judged to be legally invalid. Contracts that are common today, such as short-selling, forward delivery agreements and options were always at risk to legal challenge when the terms of the contracts were not favourable to one of the contractual parties (Dickson, 1967, Chaps. 7 and 8; Murphy, Chap. 7; Shea, 2009).

Tables and figures that follow will establish the extent to which trade in EIC shares was directly comparable to trade that was simultaneously taking place in BoE shares already described by Carlos and Neal (2006). These new EIC data are presented here for the first time and were extracted from one source, the stock ledger for 1719-23 (India Office Records, L/A/G/14/5/4). The EIC was a smaller corporation than was the BoE and had commensurately smaller body of shareholders. In 1719 and 1720 the ownership of the Company was spread over about 1700 account holders. Into 1721 and 1722, however, the ownership was spread over more than 1850 account holders and by 1723 there were more than 1900 account holders (Table 2). Between March 1719 and March 1723 there were recorded 3635 separate stock accounts. Over a comparable period between September 1720 and September 1725, there were recorded more than 7900 such BoE accounts (Carlos and Neal, 2006).

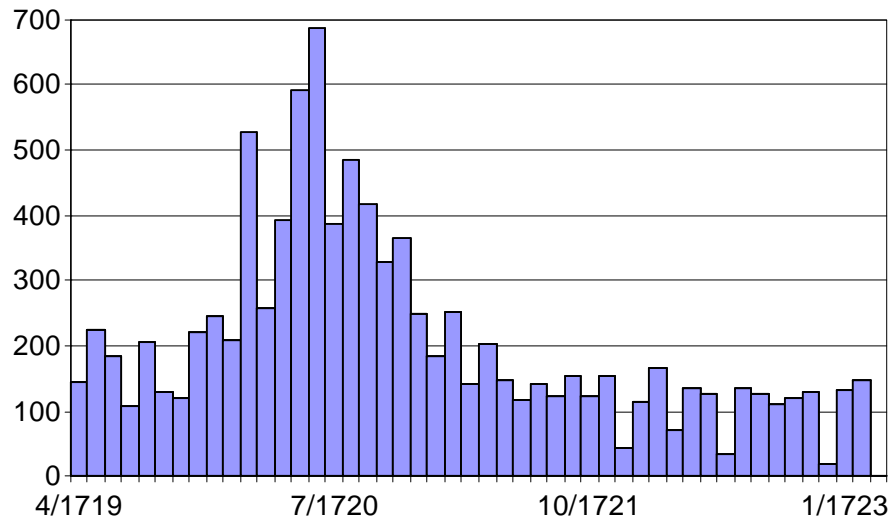
As would be expected, trade in shares was especially heavy in the Bubble year of 1720. The nominal equity capital of the BoE, which was £5.56 million, was turned

over a bit more than once in the 1720 trading year. Trade in EIC shares was more intense than that. The nominal equity capital of the EIC was £3.2 million, but in 1720 total nominal trade in its shares was nearly £5 million. This trade was composed of nearly 4900 transfers over the whole year. But there were many investors in both stocks who did not trade at all. In the two years on either side of 1720 roughly 75 percent of shareholders did not transfer any of their shares. In the Bubble year of 1720, however, more than 50 percent of shareholders were involved in transfers and once persons were involved in either sales or purchases, they engaged in more transfers on average in 1720 than they did in other years (Table 2).

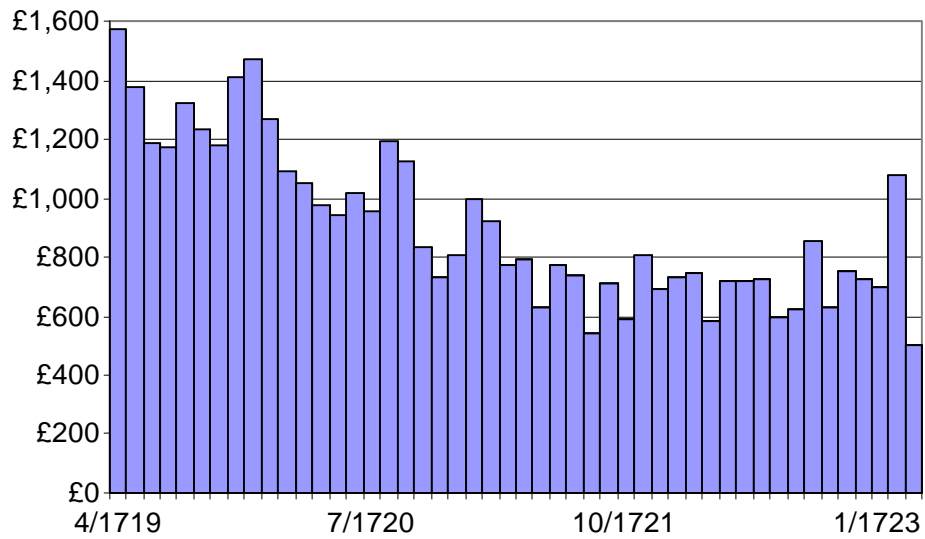
As was the case for the BoE, we can clearly document the relative intensity of trade in the Bubble year (Fig. 2). Since numbers of transfers of shares were absolutely fewer in number than the BoE transfers analysed by Carlos and Neal (2006), the relatively high turnover in EIC shares was achieved through transfers of larger size than was typically the case for BoE trade. If the reader looks to Carlos and Neal's Table 1 and compares it to our Fig. 3, one can readily confirm that EIC transfer sizes tended to be larger than transfers of BoE stock. In terms of the block size of trades, Table 1 conveys the same information.<sup>3</sup> It is particularly noticeable that block trade in the £1000-£1500 category was well represented in EIC trade in all periods, but was quite rare for BoE shares in 1720.

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<sup>3</sup> Compare this table to Table 2 and Fig. 3 in Carlos and Neal (2006).



**Fig. 2.** Monthly Numbers of East India Shares Transferred.



**Fig. 3.** East India monthly nominal value per transfer.

**Table 1****Numbers and Percents of EIC Transfers by Block Size and Time Period**

Block Size £	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723
0-99	9	57	36	39	141
100-199	41	254	172	165	632
200-299	30	244	157	119	550
300-399	29	127	108	65	329
400-499	14	61	35	37	147
500-999	432	1846	743	693	3714
1000-1499	683	1586	364	338	2971
1500-1999	37	140	42	33	252
2000-2499	170	333	48	37	588
2500-2999	17	31	15	8	71
3000-4999	76	119	44	24	263
5000+	49	99	22	18	188
Total	1587	4897	1786	1576	9846

Block Size £	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723
0-99	0.6%	1.2%	2.0%	2.5%	1.4%
100-199	2.6%	5.2%	9.6%	10.5%	6.4%
200-299	1.9%	5.0%	8.8%	7.6%	5.6%
300-399	1.8%	2.6%	6.0%	4.1%	3.3%
400-499	0.9%	1.2%	2.0%	2.3%	1.5%
500-999	27.2%	37.7%	41.6%	44.0%	37.7%
1000-1499	43.0%	32.4%	20.4%	21.4%	30.2%
1500-1999	2.3%	2.9%	2.4%	2.1%	2.6%
2000-2499	10.7%	6.8%	2.7%	2.3%	6.0%
2500-2999	1.1%	0.6%	0.8%	0.5%	0.7%
3000-4999	4.8%	2.4%	2.5%	1.5%	2.7%
5000+	3.1%	2.0%	1.2%	1.1%	1.9%

In conformity with the results of Table 3 in Carlos and Neal (2006), we find that the majority of sellers and buyers in all periods transferred stock only once or twice. For the majority of stock traders, the South Sea Bubble period could hardly be described as a period of continued and frenzied trading activity. Of all buyers and sellers in 1720, those who bought or sold more than 6 times accounted for only about 10 percent of all traders (Table 2). In conformity too with Carlos and Neal's Table 4, we find that the distribution of transfers by size was uniform between buyers and sellers (Table 3). Although EIC shareholders traded more frequently and in slightly larger block sizes than did BoE shareholders, there are very many other similarities

between the trading histories of shareholders in the two firms. Most buyers and sellers, particularly if they were small buyers and sellers, traded infrequently so that large portions of both companies' share ownership was quite stable, even through the South Sea Bubble period.

We have melded the EIC data with the Carlos and Neal Bank of England (hereafter, the BoE) data and restructured all data into a weighted multidigraph. The resulting data covers the period March 1719 through December 1721, the period for which we have both EIC and BoE stock trading data in common. Directed edges represent sales of stocks from one account holder to another and the edge weights correspond to the nominal size of the sale. Edges in the graphs have other attributes, which are changeable through time. Each edge, of course, has a date that corresponds to the date of transfer. The type of stock (EIC or BoE) transacted is also an edge-attribute. We have also been able to calculate the size of stock inventories held by each buyer and seller. Socio-economic characteristics of stock account holders are treated as node attributes and pertain to gender, professional class, social class, political class, residence, and nationality. We have of course taken the greatest care possible in indentifying persons who appear both in the BoE and EIC datasets and have assigned them common identification numbers.

A device used later in this paper is the time-series analysis of subgraphs defined by edge-dates that span a 3-month range. A monthly series of such graphs and their characteristics are used to create what amounts to moving-average trends in network characteristics. Our entire dataset contains more than 20,000 trades (edges) and more than 10,000 nodes. From this graph we create our monthly quarterly subgraphs. The size and other characteristics of these subgraphs (see Table 4) will be discussed in Section 4.

**Table 2**  
Numbers of Unique EIC Sellers and Buyers by Numbers of Transactions

Number of Transactions	Unique sellers (Number)					Unique buyers (Number)				
	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723
0	1265	841	1375	1405	586	1242	885	1323	1366	600
1	336	716	368	432	1125	342	829	535	510	1386
2	87	274	113	122	432	91	214	120	112	425
3	48	122	47	63	199	43	115	55	60	206
4	23	58	31	23	125	15	58	18	26	126
5	22	44	20	19	85	19	41	20	16	90
6	6	24	8	12	50	11	21	12	9	52
7	7	17	6	9	38	7	22	5	11	48
8	3	14	7	6	35	6	16	1	3	21
9	3	19	2	2	22	3	16	8	6	14
10	5	9	3	4	22	3	9	4	2	18
11	1	6	2	3	13	1	15	1	1	12
12	3	9	1	1	8	2	8	2	1	15
13	3	5	1	2	7	1	5	3	4	10
14	0	5	1	2	15	2	4	2	2	10
15+	12	60	21	8	116	12	53	17	7	110
Sum Sellers/Buyers (with 1 or more transactions)	559	1382	631	708	2292	558	1426	803	770	2543
Number Owners, Beginning of Year					Number Owners, End of Year					
	1714	1694	1846	1969	1714	1694	1846	1969	1995	1995
Percentage of Owners who never sold					Percentage of Owners who never bought					
	73.8%	49.6%	74.5%	71.4%	34.2%	73.3%	47.9%	67.2%	68.5%	30.1%
Average Number of transactions per seller					Average Number of transactions per buyer					
	2.3	2.8	2.4	2.1	3.1	2.3	2.7	2.1	2.0	2.8

**Table 3**  
Unique EIC Sellers and Buyers by Largest Transactions

Block Size £	Unique Sellers (Number)					Unique Buyers (Number)				
	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723
0-99	4	11	12	17	38	4	10	17	7	25
100-199	18	66	60	61	172	26	106	83	100	215
200-299	14	79	57	60	169	8	91	89	61	187
300-399	15	46	45	34	116	16	38	52	33	100
400-499	5	23	10	16	46	6	21	17	23	50
500-999	164	434	214	258	808	150	437	264	283	784
1000-1499	180	398	131	169	573	191	414	161	170	631
1500-1999	22	57	21	21	80	22	58	30	22	99
2000-2499	67	139	26	27	133	65	120	30	28	198
2500-2999	7	18	9	5	21	7	16	8	7	34
3000-4999	33	52	29	22	75	38	53	34	19	119
5000+	30	59	17	18	61	25	62	18	17	101
Total	559	1382	631	708	2292	558	1426	803	770	2543

Block Size £	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723	4/1719-12/1719	1720	1721	1722-3/1723	4/1719-3/1723
0-99	0.7%	0.8%	1.9%	2.4%	1.7%	0.7%	0.7%	2.1%	0.9%	1.0%
100-199	3.2%	4.8%	9.5%	8.6%	7.5%	4.7%	7.4%	10.3%	13.0%	8.5%
200-299	2.5%	5.7%	9.0%	8.5%	7.4%	1.4%	6.4%	11.1%	7.9%	7.4%
300-399	2.7%	3.3%	7.1%	4.8%	5.1%	2.9%	2.7%	6.5%	4.3%	3.9%
400-499	0.9%	1.7%	1.6%	2.3%	2.0%	1.1%	1.5%	2.1%	3.0%	2.0%
500-999	29.3%	31.4%	33.9%	36.4%	35.3%	26.9%	30.6%	32.9%	36.8%	30.8%
1000-1499	32.2%	28.8%	20.8%	23.9%	25.0%	34.2%	29.0%	20.0%	22.1%	24.8%
1500-1999	3.9%	4.1%	3.3%	3.0%	3.5%	3.9%	4.1%	3.7%	2.9%	3.9%
2000-2499	12.0%	10.1%	4.1%	3.8%	5.8%	11.6%	8.4%	3.7%	3.6%	7.8%
2500-2999	1.3%	1.3%	1.4%	0.7%	0.9%	1.3%	1.1%	1.0%	0.9%	1.3%
3000-4999	5.9%	3.8%	4.6%	3.1%	3.3%	6.8%	3.7%	4.2%	2.5%	4.7%
5000+	5.4%	4.3%	2.7%	2.5%	2.7%	4.5%	4.3%	2.2%	2.2%	4.0%

### 3. A flow network with inventories, pass-through and immediacy

In this section we formally define an enclosed flow network for trade in stocks and several measures useful for the description of intermediation within that network. The network is enclosed because there is neither an exterior source of flows nor is there an exterior sink to receive flows, yet every node can be a stopping place for flows. The accumulated flows at any node we call inventories. Inventories can reside at a node indefinitely and are limited in size only by the total amount of stock contained within the network. Inventories that reside at a node for a period are said to have vintage. How fast stock changes hands, or to be more precise, how fast stock passes through nodes will be measured by what is called immediacy, which as shall be shown in Eq. 1, is a function of changes in inventory vintages.

Consider a multidigraph defined on a set of nodes  $\{Z\}$ . Each node represents a stock account. Stock transfers are directed flows that pass between nodes, one node signifying the seller and the other node signifying the buyer. In our sources the date of stock purchases and sales for every account are recorded. Stock trade is frequent enough so that posted dates of trade are almost, but not completely, continuous across the calendar; besides the cessation of trade that occurred on Sundays and holidays, companies themselves would stop transfers of stock so that important accounting tasks, such as the payment of dividends, could be undertaken. It will therefore be important for us to distinguish between time periods (labelled  $t$ ) and the number of calendar days within a time period,  $L(t)$ .  $L(t)$  is the length (in days) of the period between  $t-1$  and  $t$ .

The  $i$ -th instance of a flow between two nodes  $\{u,w\}$  in period  $t$  is denoted  $f_i(t,u,w)$ , with  $f_i(t,u,w) \geq 0$ ,  $u, w \in Z$ . The number of such flows in period  $t$  is denoted



$N_{tuw}$ . Let  $S_{tuw} = \{1, \dots, N_{tuw}\}$  and define total flows as  $f(t, u, w) = \sum_{i \in S_{tuw}} f_i(u, w)$ . For

the same period  $t$ , we define net flows from  $u$  to  $w$  to be  $F(t, u, w) = f(t, u, w) - f(t, w, u)$ .

It follows naturally that  $F(t, u, w) = -F(t, w, u)$ .

A primitive and ultimately unsatisfactory way of discovering a node's importance as an intermediary is to simply count and illustrate its degree. This was the approach taken by Carlos, Neal and Wandschneider (2007) for BoE share trade. We can do much the same by defining a measure of a node's (node  $u$ ) joint in-degree

and out-degree as the  $\left\{ \sum_{w \in Z} N_{wu}, \sum_{w \in Z} N_{uw} \right\}$ -tuple and the nodes' degree sum as

$DS_u = \sum_{w \in Z} N_{wu} + \sum_{w \in Z} N_{uw}$ . The set of all nodes with a stated maximum (MAX) of

degree sums is  $\{u \in Z : DS_u \leq \text{MAX}\}$  and from the simple cardinality (#) of this set

relative to the cardinality of  $Z$  itself we can build a cumulative distribution of degree

sums over any range of MAX of interest to us. In Fig. 4 we plot for the two stocks

and different periods the ratio  $\#\{u \in Z : DS_u \leq \text{MAX}\} / \#Z$  for  $2 \leq \text{MAX} \leq 26$ . The

figure re-summarises some facts that were presented in Section 2. First, in the Bubble

year of 1720, all stocks were traded more frequently. In Fig. 4 therefore both stocks'

degree-sum distributions for 1720 appear shifted to the right relative to their positions

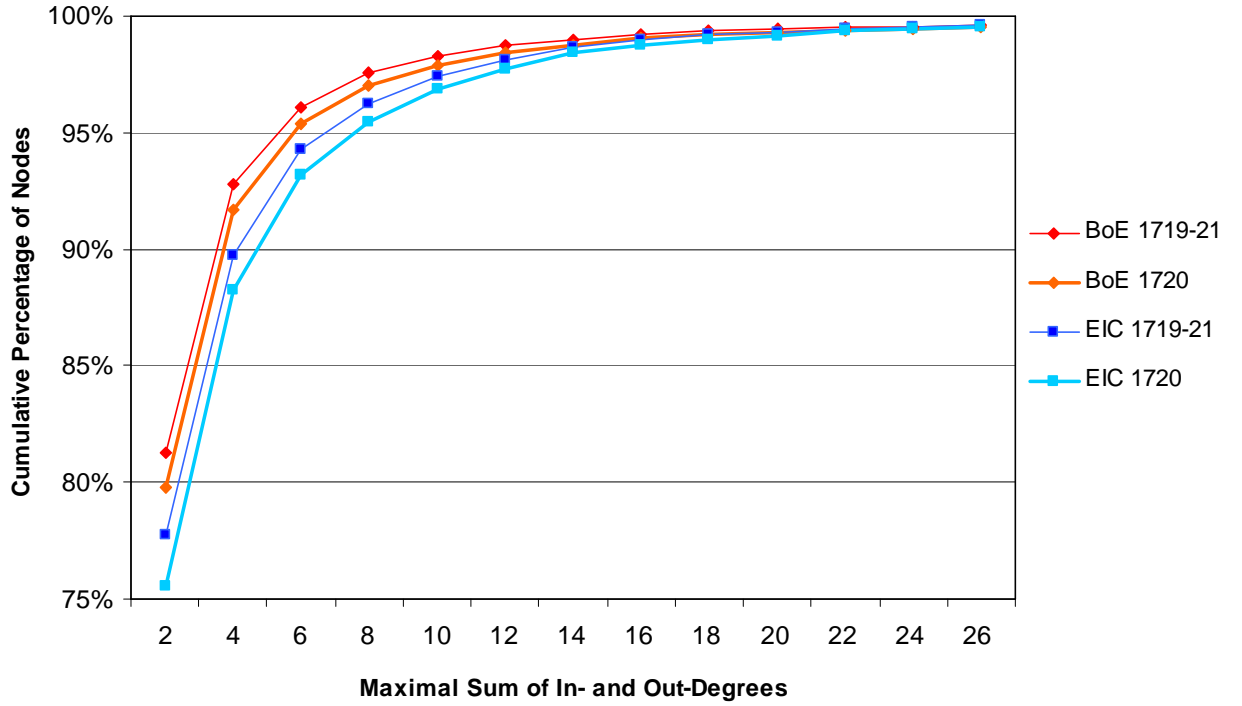
in other years. Second, the figure also shows that trade in EIC stocks was more

frequent than was trade in BoE stocks, in all years and in 1720 in particular. But these

exercises miss out other network features that are associated with intermediation - the

extent and duration with which trade flows stop at nodes. These features are node

inventories and their vintages.



**Fig. 4.** Cumulative distribution of node degree sums for networks of Bank of England (BoE) and East India Company (EIC) stock trades in the periods 1719-21 and 1720, separately.

Inventories are the accumulated net flows that come to a node over some length of time. The sum of all net flows towards node  $w$  is the change in  $w$ 's stock inventory,  $\Delta_w(t) = \sum_{u \in Z} F(t, u, w)$ . Let  $H = \{0, \dots, T\}$ . Stock inventories accumulated at node  $w$  by time  $T$  are  $I_w(T) = \sum_{t \in H} \Delta_w(t)$ . Since our networks are enclosed, the sum of all inventories is always a constant and it follows that the sum of all net flows within the network will always have to sum to zero;  $\sum_{w \in Z} \Delta_w(t) = 0$ , for any  $t$ .

We must now come to a formal definition of inventory vintage. Vintage will be defined in a recursion formula (Eq. 1), so we must start with a description of the recursive process that gives rise to the formula. Consider the flow network in an initial state. The reader can suppose that at  $t=0$  the total inventory of stock resides at

just one node, which represents the company. This would be the situation before stock is first offered to the public by the company. From the date that the company starts to distribute stock to investors, we can measure not only the size of investors' inventories, but we can also calculate the average length of time that such inventories are held. This is what is called inventory vintage. Let  $V_w(t)$  denote the vintage of inventories at node  $w$  in period  $t$ . For all  $w$ , excepting the company, both  $I_w(0)$  and  $V_w(0)$  are equal to zero. Suppose now that the company begins to distribute its stock at  $t=1$ . It follows that  $I_w(1) > 0$  and  $V_w(1) = L(1)$  for all  $w$  that have received stock from the company. Suppose that after  $t=1$  it is then possible for all nodes to begin to trade stock. Between  $t$  and  $t+1$ , inventories that remain at a node from the previous period will increase in vintage by  $L(t+1)$  days. In the same period, newly added inventories will also add  $L(t+1)$  days to existing vintage. This is a LIFO ('last-in-first-out') construction of vintage and from it a recursion occurs between  $V_w(t)$  and  $V_w(t+1)$ , which is

$$V_w(t+1) = \frac{(I_w(t) + \min[0, \Delta_w(t+1)]) \times (V_w(t) + L(t+1)) + \max[0, \Delta_w(t+1)] \times L(t+1)}{I_w(t+1)}. \quad (1)$$

Inventories and their vintages are the primitive building blocks for measures that are useful in analysing network trade and intermediation. These measures we call pass-through and immediacy. Pass-through measures the extent to which a node facilitates flows through a network. The idea of immediacy is concerned with the speed with which outward flows (sales) are effected. Sales that are simultaneous with purchases are absolutely immediate and are synonymous with pass-through. But at other nodes sales may come from inventories. These are sales that are net of purchases and will be, of course, not as immediate as is pass-through. Average

immediacy of sales will have to exceed zero if there are sales from nodes that are in excess of pass-through.

Formally we define pass-through (PT) to be the portion of flows into a node that does not positively contribute to the node's inventories:

$$PT_w(t) = \min \left[ \sum_{u \in Z} f(t, w, u), \sum_{u \in Z} f(t, u, w) \right] = \sum_{u \in Z} f(t, w, u) + \min[0, \Delta_w(t)]. \quad (2)$$

Unlike in a pneumatic flow network, whose network edges will generally have capacity constraints upon them, there is no intrinsic limit to PT through any node or in the network as a whole. This we can readily confirm from (2) by summing over all nodes' PT,

$$\sum_{w \in Z} PT_w(t) = \underbrace{\sum_{w \in Z} \sum_{u \in Z} f(t, w, u)}_{\text{Total Sales}} + \sum_{w \in Z} \min[0, \Delta_w(t)]. \quad (3)$$

Eq. 3 also tells us that Total Sales is the natural choice for a normalisation factor for pass-through. Since we shall hereafter examine only such normalised units of PT, it will make no difference that we cannot observe market transfer values in our data sources; PT per unit of Total Sales will be the same regardless of whether sales are measured in nominal or market-valued units.<sup>4</sup>

Immediacy is zero for the PT portion of sales, as we have written, and will be a positive function of any inventories (and their vintages) that are used to complete sales over and above PT. Formally, immediacy of sales from node  $w$  is

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<sup>4</sup> cf. fn. 2.

$$IM_w(t) = \frac{\max[0, -\Delta_w(t)] \times V_w(t)}{\sum_{u \in Z} f(t, w, u)}. \quad (4)$$

For stocks that are sold in period  $t$ ,  $IM_w(t)$  represents the average number of days that the stocks have been in node  $w$ 's inventories. The numerator of Eq. 4 is the amount by which inventories are used to make sales, weighted by the vintage of those inventories. The denominator is node  $w$ 's total sales. Large sales from very old inventories will make for large values of  $IM_w(t)$ . If we were to try to compare immediacy in different periods that contained different numbers of days with in them, then calculated  $IM_w(t)$  numbers would have to be normalised by  $L(t)$ . That necessity does not arise in this paper's analyses.

A useful way to see the connection between PT and immediacy is to consider two different styles of intermediation – brokerage and dealership. Brokerage refers to the facilitation of trade without the use of inventories. A pure broker would be like an estate-agent who brings buyer and seller together, but who does not own the property that is the object of the transaction.<sup>5</sup> There were traders whose inventories were quite small relative to the PT they facilitated. These persons will be the intermediaries who most closely resemble pure brokers. Traders who happen to carry large inventories relative to the PT they facilitate are acting more like dealers. Even though dealers have inventories, their sales can be as immediate as are brokers' sales. As long as sales do not draw down a dealer's inventories, his sales will be absolutely immediate. The reader will now appreciate why a LIFO construction was chosen for vintage in Eq. 1. A FIFO ('first-in-first-out') construction was possible, but an assumption

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<sup>5</sup> If all intermediation was pure brokerage, then intermediation would be completely undetectable in our data. cf. fn. 8.

behind such a construction would be that dealers' sales always start from inventories. This would mean that dealers could never achieve absolute immediacy in sales. It is unreasonable to require that this should be so. If we view inventories as just one of the several means to the end of providing intermediation services, there is no reason why the two styles of intermediation cannot exist together and provide, in competition with each other, equally immediate intermediation.

In this section we have defined the basic structure of a flow network from its basic building blocks up to some important functions that will be needed to detect intermediation within the network. To write that a node is a trading intermediate is to claim that the node is in certain ways 'central' in a network of flows. The innovative feature of PT as a description of how well a node is connected and how central it is within a network is that it accounts for the possibility that flows can stop and linger at nodes; pass-through itself is not only a dynamic node attribute, it affects what amounts to another dynamic node attribute, the node's inventories. Immediacy is yet another dynamic node attribute. It measures the speed with which outward flows (sales) move away from nodes. In the next section we describe how PT can be used to define a component structure of our networks.

#### **4. Network components**

The trading networks of 1719-21 were of large-scale and to make sense of them we need to investigate their component structure. It might be expected, for example, that the networks have densely-connected central components and other less-densely connected peripheral components, as does the World Wide Web (Broder, A., Kumar, R., et. al., 2000). Up to now we have reasoned that intermediaries have to experience

pass-through (PT). So, how can we use PT to identify the network components that are most likely to contain intermediaries and the trade flows they facilitate?

Table 2 illustrates one obvious way in which our networks have component structure. The table indicates that there were many owners of stocks who traded not at all or who traded only once in any time period. These owner-nodes are completely isolated or are nearly isolated because they experience no PT. Surrounded by these very large peripheries there are connected components and, although they cannot be called giant connected components in terms of the percentage of all nodes that they contain, they are large in terms of the amount of trade and the intermediation they contain. Although nodes with PT will have to be connected with other nodes, how completely are all nodes with PT connected with each other? We hypothesise that a node that facilitates PT is more likely to represent a central financial intermediary if it is connected to other nodes that similarly facilitate PT. Thus we come to a notion of what we call core pass-through (CPT). A node facilitates CPT if it has PT and it is connected (via PT) with other nodes that also facilitate PT. Formally the set of nodes that reside in this core is defined  $\{w \in Z : PT_w > 0, F(w, u) \neq 0, u \in Z \text{ s.t. } PT_u > 0\}$ . It is within this core that we expect to find the nodes that are most closely associated with financial intermediaries of interest to us. The size of this core relative to the other trading components may indicate the importance of specialist intermediaries during the South Sea Bubble.

Table 4 describes the dimensions of the overlapping, quarterly subgraphs that will illustrate the changing patterns in intermediation that we hope to discover. For trade in each stock the subgraphs' sizes in terms of flows (sales) and the number of nodes are displayed.<sup>6</sup> The numbers of nominal £100-shares traded are displayed in the

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first six columns of the table. In the columns labelled ‘Traders’ the numbers of unique traders are reported. These nodes represent all persons who ever traded during the quarter. The columns labelled ‘Largest Trading Component’ refer to the largest components that are simply connected by trade flows. The table also displays the size of the next largest components. Nestled within the Largest Trading Components are the PT and CPT components.

Fig. 5 visually summarises the differences between the networks for BoE and EIC stock trade in terms of PT and CPT components. EIC PT was a larger percentage of trade and was composed of a larger, densely-connected core network than was the case for BoE PT. Over time, as well, there occurred a change in these large-scale components. After 1720, PT declined as a percentage of total sales and CPT declined as a percentage of PT. These observations are consistent with a shrinking in intermediation and a decline in its compactness, although the decline in compactness is small in the case of trade in EIC shares.

Fig. 5 also suggests that the largest changes in the size of PT and CPT components occurred immediately after 1720. Two possible interpretations come to mind: i) If PT and CPT component measures are perfectly adequate in identifying the timing with which changes to intermediation occurred, then the events of midsummer 1720 more likely caused declines in intermediation than were declines in intermediation a contributor to the events of midsummer 1720; ii) or possibly these component measures themselves are not refined enough to detect the most significant changes in intermediation. To the latter interpretation the first natural response would be to look further into CPT to see if we can find even denser concentrations of PT than described by the whole of CPT itself. This is indeed possible.

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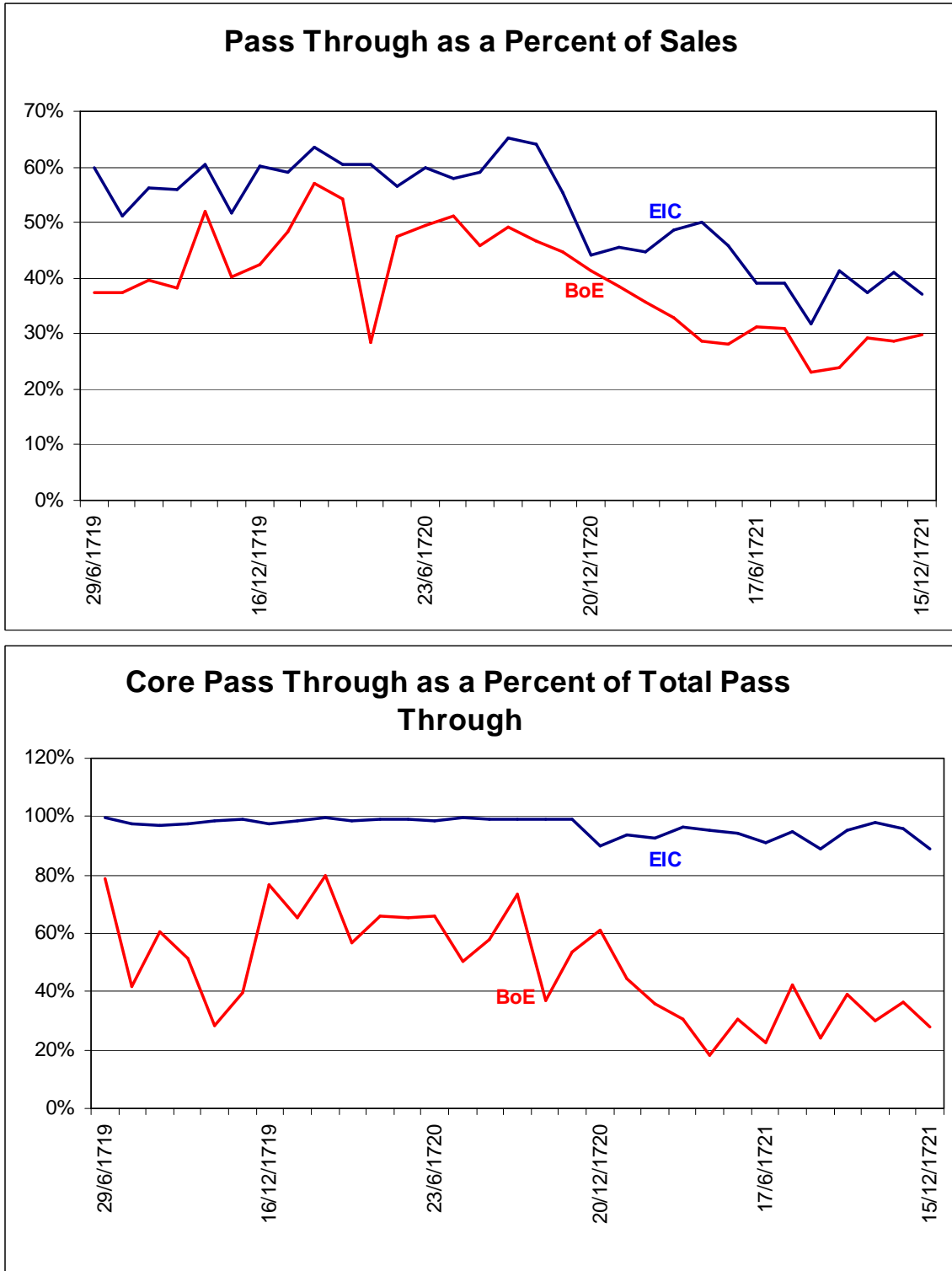
<sup>6</sup> Edge counts for each subgraph and its components have also been prepared, but are omitted from the table for the sake of brevity.



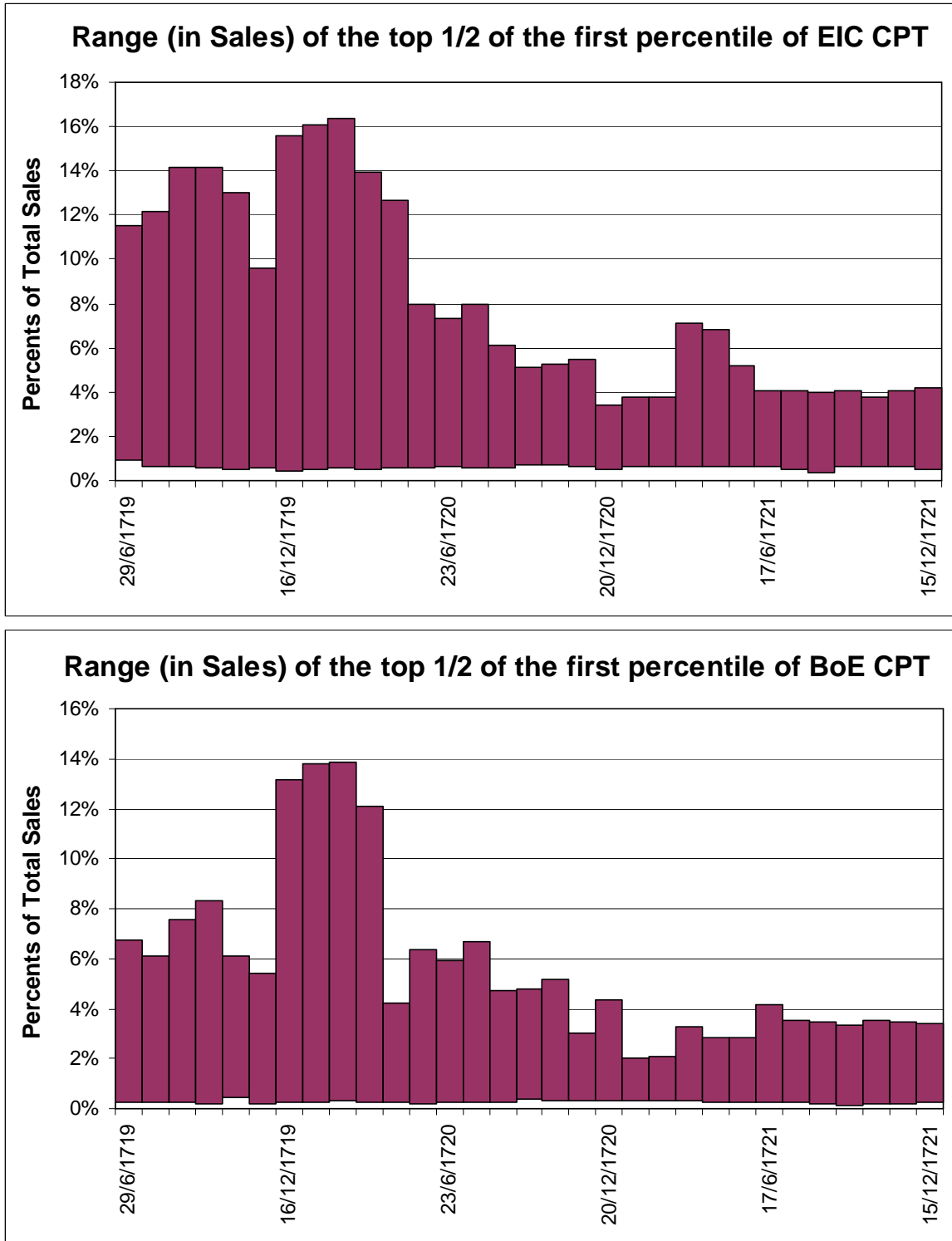
Outside of those nodes that could account for the top first percentile of CPT, there were no nodes that could account for any more than the tiniest fraction of a percent of total sales. But amongst the nodes that did command the top first percentile of CPT, there were small numbers of nodes that commanded very large percentages of total sales. Fig. 6 illustrates the range of percentages of total sales that were attributable to these top CPT-trading nodes. These top traders were generally members of a professional financier class, the goldsmith bankers along with a smaller number of professional brokers whose fate is the subject of the next section. It is clear that the heyday of such top CPT-traders occurred before the South Sea Bubble. The foremost CPT-trader who could intermediate at least 10 p.c. of all trade was a creature of the pre-Bubble period. Fig. 6 thus paints a different picture than does Fig.5 about changes in intermediation around the South Sea Bubble. The trends associated with PT and CPT suggest there were declines in intermediation after the Bubble's bursting, but there were signs too that, even before the Bubble started, all was not well amongst the most important intermediaries. The timing with which the topmost CPT-traders relinquished their dominant shares in total sales coincides with the beginning of the end for the goldsmith bankers and brokers, which is the subject of the next section.

**Table 4**  
**Quarterly Subgraphs' Component Sizes in terms of Flows and Nodes**

Quarter ending	Numbers of Shares Traded in the Quarterly Subgraphs and their Components						Numbers of Nodes in the Quarterly Subgraphs and their Components									
	BoE			EIC			BoE					EIC				
	CPT	PT	Total Sales	CPT	PT	Total Sales	CPT	PT	Largest Trading Component	Next Largest Trading Component	Traders	CPT	PT	Largest Trading Component	Next Largest Trading Component	Traders
6/1719	1,277	1,625	4,338	4,533	4,550	7,597	35	70	333	6	2940	105	108	300	7	590
7/1719	648	1,555	4,159	2,959	3,037	5,930	18	74	322	6	2941	75	85	276	5	1831
8/1719	1,036	1,707	4,317	3,338	3,442	6,129	28	85	372	4	2975	71	84	287	4	1832
9/1719	969	1,883	4,925	2,995	3,072	5,485	27	91	405	5	2997	67	78	256	3	1812
10/1719	708	2,478	4,766	3,431	3,483	5,754	14	123	368	5	2969	72	80	270	3	1810
11/1719	724	1,821	4,543	2,839	2,869	5,540	21	90	334	8	2964	80	84	251	4	1800
12/1719	2,150	2,807	6,627	4,381	4,488	7,450	44	99	381	6	3004	104	113	346	7	1832
1/1720	2,635	4,041	8,354	4,870	4,929	8,346	40	121	457	7	3533	106	115	349	5	1837
2/1720	7,760	9,747	17,101	7,366	7,401	11,624	146	286	900	8	3708	190	197	505	4	1878
3/1720	5,284	9,294	17,093	6,627	6,719	11,128	59	291	981	4	3738	190	206	543	5	1924
4/1720	838	1,272	4,486	7,202	7,263	12,008	30	80	1150	5	3330	227	237	608	4	1931
5/1720	5,511	8,429	17,735	6,409	6,464	11,430	201	422	1307	6	3413	243	250	616	5	1892
6/1720	7,190	10,929	22,119	9,610	9,773	16,334	216	555	1687	5	3654	325	351	874	5	2031
7/1720	5,558	10,979	21,408	8,994	9,049	15,640	124	550	1676	5	3690	312	324	873	6	2019
8/1720	4,301	7,427	16,162	8,429	8,486	14,386	136	438	1325	5	3423	316	330	794	5	1976
9/1720	4,998	6,830	13,875	7,341	7,404	11,355	152	342	1040	8	3278	225	232	511	7	1823
10/1720	2,211	5,964	12,743	8,901	8,958	13,991	49	262	895	7	3269	252	264	623	5	1929
11/1720	2,904	5,410	12,102	6,886	6,934	12,521	77	261	957	6	3358	206	219	628	4	1951
12/1720	2,393	3,935	9,501	3,810	4,234	9,613	89	236	816	6	3326	183	196	616	4	1987
1/1721	1,645	3,708	9,625	2,682	2,867	6,282	82	268	836	11	3808	139	154	472	4	1981
2/1721	914	2,535	7,127	2,470	2,658	5,935	31	186	687	6	3823	116	132	412	5	2001
3/1721	548	1,785	5,425	2,680	2,781	5,702	26	157	590	6	3259	99	109	350	9	2041
4/1721	209	1,137	3,951	2,609	2,741	5,485	17	106	444	7	3176	102	113	342	6	2039
5/1721	333	1,084	3,849	2,038	2,159	4,713	30	113	437	13	3215	93	108	348	6	2062
6/1721	224	994	3,183	1,141	1,254	3,198	21	95	365	10	3167	58	74	280	6	2071
7/1721	500	1,182	3,807	1,140	1,202	3,067	25	108	405	17	3211	70	81	283	5	2074
8/1721	175	723	3,120	741	832	2,617	13	82	325	9	3179	54	74	252	7	2081
9/1721	316	807	3,373	974	1,021	2,473	29	107	375	6	3195	63	74	237	10	2077
10/1721	230	766	2,613	998	1,020	2,724	11	96	260	6	3116	72	79	266	7	2079
11/1721	280	769	2,671	977	1,016	2,479	15	71	273	12	3147	65	74	245	4	2068
12/1721	211	757	2,542	936	1,056	2,855	17	69	251	6	3130	64	77	258	4	2088



**Fig. 5.** Pass through and core pass through for Bank of England (BoE) and East India Company (EIC) stock trade.



**Fig.6.** The range in terms of percents of total sales of the top one-half of the first percentile of Bank of England (BoE) and East India Company (EIC) core pass-through (CPT).

## 5. The demise of the goldsmith bankers and brokers

Reputed to be at the centre of the financial community in London were the goldsmith bankers and a group of professional brokers, hereafter referred to as the GSBs. This section is devoted to an examination of the collective experience of this group. The Bubble literature is replete with accounts of individuals from this group who were prominently active during the Bubble and suffered as a consequence of it. First and foremost amongst these accounts concerns the collapse of the Swordblade Bank partnership, the South Sea Company's own bankers.<sup>7</sup> Other prominent bankers were exposed to unique risks that were generated by their clients. Neal (1994) shows how George Middleton's association with Lord Londonderry contributed to Middleton's temporary, but prolonged, troubles. Dickson (1967) relates also how a prominent Dutch bank collapsed because it was overly vulnerable to the losses incurred by Sir Justus Beck in 1720. But until now there has been no statistical description of the collective activities of this group.

We have been able to identify 240 persons who can be positively classified either as goldsmith bankers or professional stock brokers.<sup>8</sup> Aside from the most famous names, many of these persons identify themselves as GSBs in our EIC sources. We have managed to identify many others from BoE sources, sources related

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<sup>7</sup> Dickson (Chapter 7, 1967) recounts the final fall of the partnership at the end of September 1720. Shea (2009) recounts the legal difficulties of one of the partners in the post-Bubble period.

<sup>8</sup> It appears to us that by 1720 most all sworn brokers whom we have been able to indentify carried on some stock trade on their own accounts. Brokers sworn to the City of London Aldermen were legally prohibited (by Acts of 1697 and 1708) from dealing in stocks on their own account, but nevertheless they appear in our sources with active EIC and BoE stock accounts. Although we do know of a handful of sworn brokers who do not appear in the EIC or BoE stock ledgers at all (such as Pheasant Crisp, whose brokering relations with the Duke of Portland are discussed in Shea (2009)), all the dealers and brokers in stock who did business with South Sea Company directors (see Box 158 "Brokers Accounts", HLRO Parchment Collection) appear as holders of stocks in EIC and BoE records. How much intermediation business was absolutely pure brokerage is impossible to determine in the absence of brokers' personal records of trade.

to the Royal African Company and with some help from other sources.<sup>9</sup> Within this group two important goldsmith banker partnerships require remark: the aforesaid Swordblade Bank and Child & Co. In the EIC ledgers the three Swordblade partners (Jacob Sawbridge, Elias Turner and Sir George Caswall) each have separate accounts and there is also a small and dormant account in the name of the Swordblade partnership itself. Turner appears to occupy a position in the EIC accounts analogous to the position occupied by Sir George Caswall in the BoE accounts. The Swordblade partners were respectively specialised in trade in BoE shares (Caswall) and in trade in EIC shares (Turner). The Child & Company partnership was represented in substantial EIC accounts for each of the six partners who were living in our period.<sup>10</sup> Francis and Sir Robert Child were special since they also served in the EIC Directorship. At any time the holdings of these two banking partnerships together accounted for about one-third of all GSB holdings of EIC stock. The Swordblade's holdings were smaller and more volatile than were the Child & Co. holdings. Child & Co. survived the Bubble and their holdings of EIC, as well as of BoE stock, were substantial and steady throughout the crisis.

What can be immediately affirmed in Figs. 7 and 8 is that prior to the South Sea Bubble, GSBs were involved in at least 50 percent and as much as 75 percent of all transactions in the case of EIC stock. Their market shares in all transactions declined most rapidly before the market boom was fully underway in midsummer 1720. One could never assert that GSBs were totally eliminated from the markets thereafter, but

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<sup>9</sup> Professional descriptions variously appear in stock journals and stock ledgers for the EIC, BoE and the Royal African Company. The sources for the last company are found in the T70 series of documents on deposit at the National Archives, Kew. Until recently Price's (1876) list was the most comprehensive list of early 18<sup>th</sup>-century of London bankers, but it is now quite eclipsed by the list compiled by the professional banknote dealer, Roger Outing, [http://www.banknotes4u.co.uk/english\\_banks.htm](http://www.banknotes4u.co.uk/english_banks.htm).

<sup>10</sup> These were Francis Child, Sir Robert Child, John Morse, Henry Rogers, Samuel Child and Henry Morse.

their dominance was certainly finished by the end of 1720. The GSB retreat from the markets was markedly faster from the EIC share markets than it was from the BoE markets. There was also a marked decline in inter-GSB trade, which would be consistent with the shrinkage in CPT that was discussed in the previous section. Figs. 7 and 8 also illustrate the inventories that were in the possession of GSBs were very substantial inventories.

Even though they did indeed command very large inventories, GSBs were largely brokers; their inventories were not so large relative to the amounts of CPT they facilitated (top panels, Figs. 9 and 10). With the demise of the GSBs intermediation did not end, but was placed on a different footing – one that depended upon dealership more than it depended upon brokerage. Persons, largely of the merchant class, who were already substantial investors took over from GSBs in the facilitation of PT and CPT. During the Bubble itself such facilitators also included company directors themselves, but for the most part they were foreign merchants or were British-domiciled Jews, also largely of the merchant class.<sup>11</sup> This is clearest in the case of EIC stock (lower panel, Fig. 9). In BoE trade, dealership also displaced brokerage, although it is more difficult to see trends in this regard by social affiliations (lower panel, Fig. 10) because BoE CPT itself became quite small and more volatile as a component of Total Sales and PT (Table 4). The path towards dis-intermediation was thus marked by highly volatile inventory behaviour by the formerly dominant intermediaries – the GSBs. And with their decline and demise as intermediaries, the form of intermediation itself moved from brokerage to dealership.

GSBs began to withdraw their intermediation services from the markets for EIC and BoE shares well before the peak in the Bubble. This can be observed in terms of

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<sup>11</sup> A survey of the general relations amongst the Jewish merchant class of London at this time is found in Carlos, Maguire and Neal (2008).

either transactions (Figs. 7 and 8) or in terms of their dominance in CPT (Figs. 9 and 10). At the same time that GSBs were selling their inventories of EIC stock, they tended to accumulate inventories of BoE stock (lower panels, Figs. 7 and 8). In one interpretation, both the withdrawal of GSB-intermediation services in EIC and BoE markets and the shift in inventories away from the relatively risky EIC shares towards BoE shares would be consistent with a view that GSBs were in the midst of credit crisis even before the South Sea scheme was fully underway. We have good secondary evidence that as early as March and April of 1720 the interest costs of short-term credit were high.<sup>12</sup> This could have been as indicative of high demand for credit as well as it could have indicated a shortage in the supply of it. Dickson (1967) and Neal (1990) have both given accounts of how, with the collapse in asset values in France in early 1720, financial capital came from the continent to London to create high demand for assets, trade in assets and credit. But intermediaries in England might also have suffered from the collapse of asset values in France. If their net asset values were adversely affected by the collapse of the Law system, that may have reduced their willingness to supply intermediation services in London and that too would have been consistent with both higher costs of credit and in a movement in inventories away from risky assets (EIC stock) to less risky assets (BoE stock).<sup>13</sup>

The GSB withdrawal from market intermediation was not only collective, but was also experienced at the very pinnacle of the GSB community. Intermediation was distributed in a highly skewed fashion across financial intermediaries. It has already

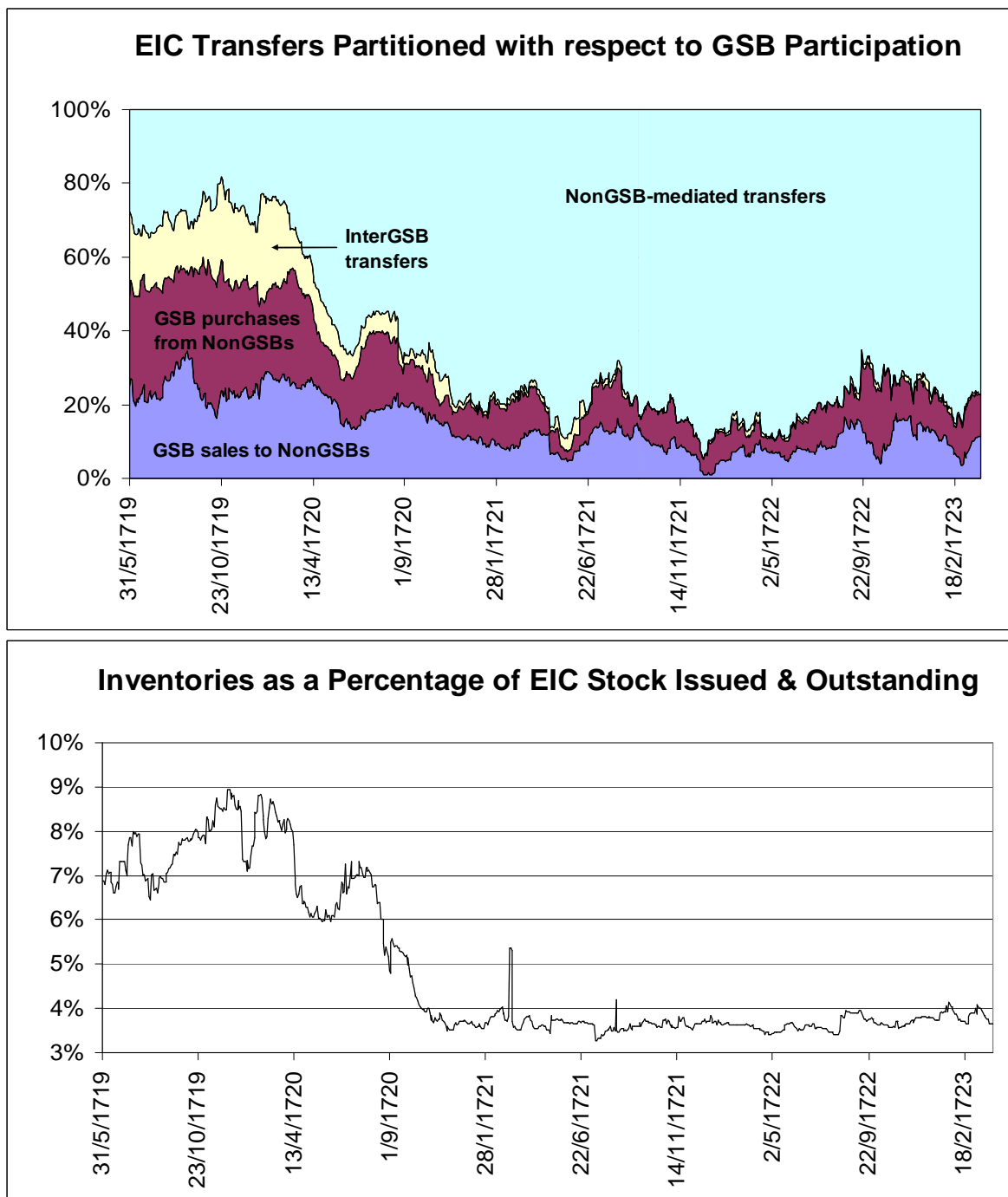
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<sup>12</sup> 10 p.c. per month was claimed as the cost of credit by George Middleton (Neal, 1994) and Hutcheson (1720) also stated such were the terms for credit in March and April of 1720.

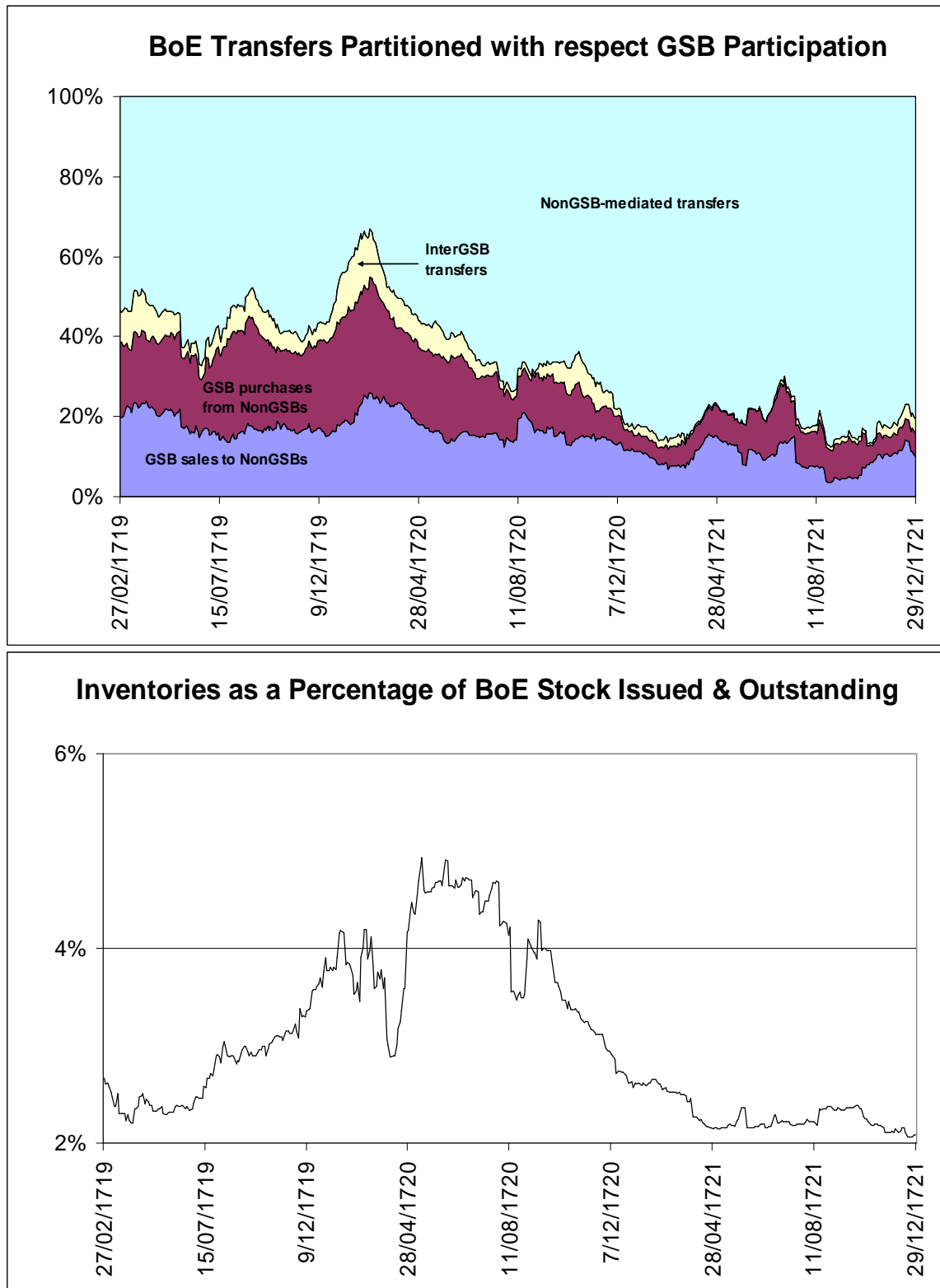
<sup>13</sup> In period 1719-21 there was considerable risk of return to both EIC and BoE stocks. The standard deviation of returns was 1.9 per cent per diem (p.c.p.d.) for EIC stocks and 1.7 p.c.p.d. for BoE stocks. A shift from more risky to less risky assets in an effort to avoid losses in a crisis is sometimes referred to as a "flight to quality".



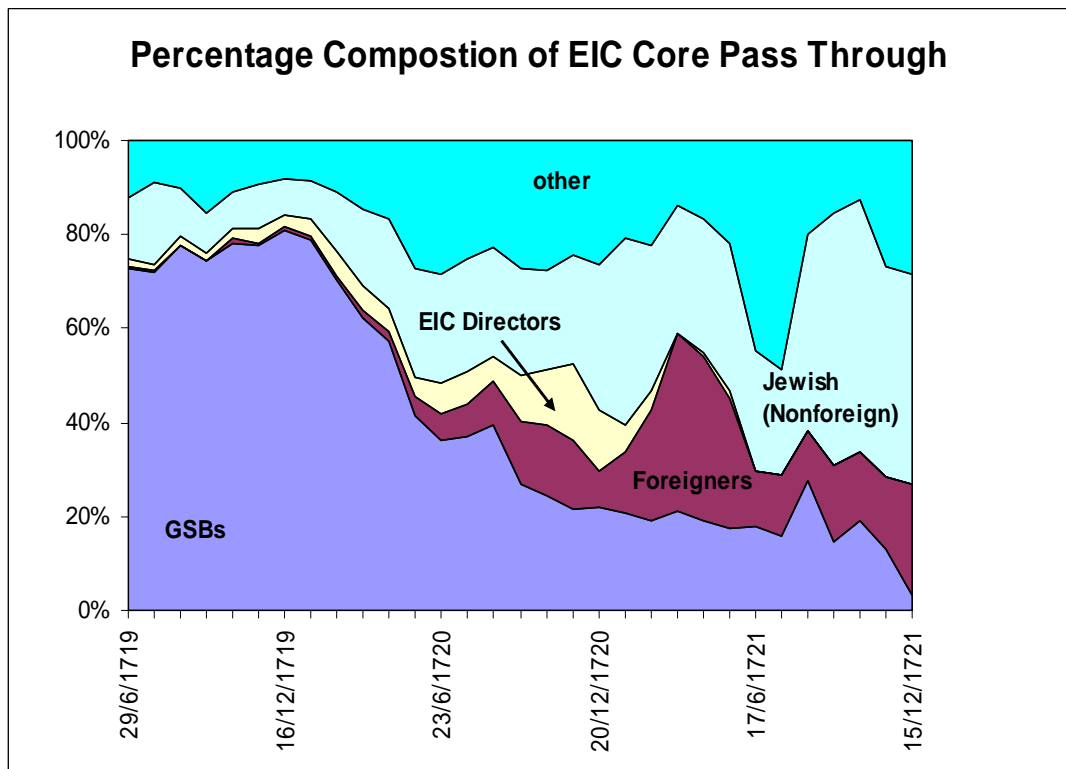
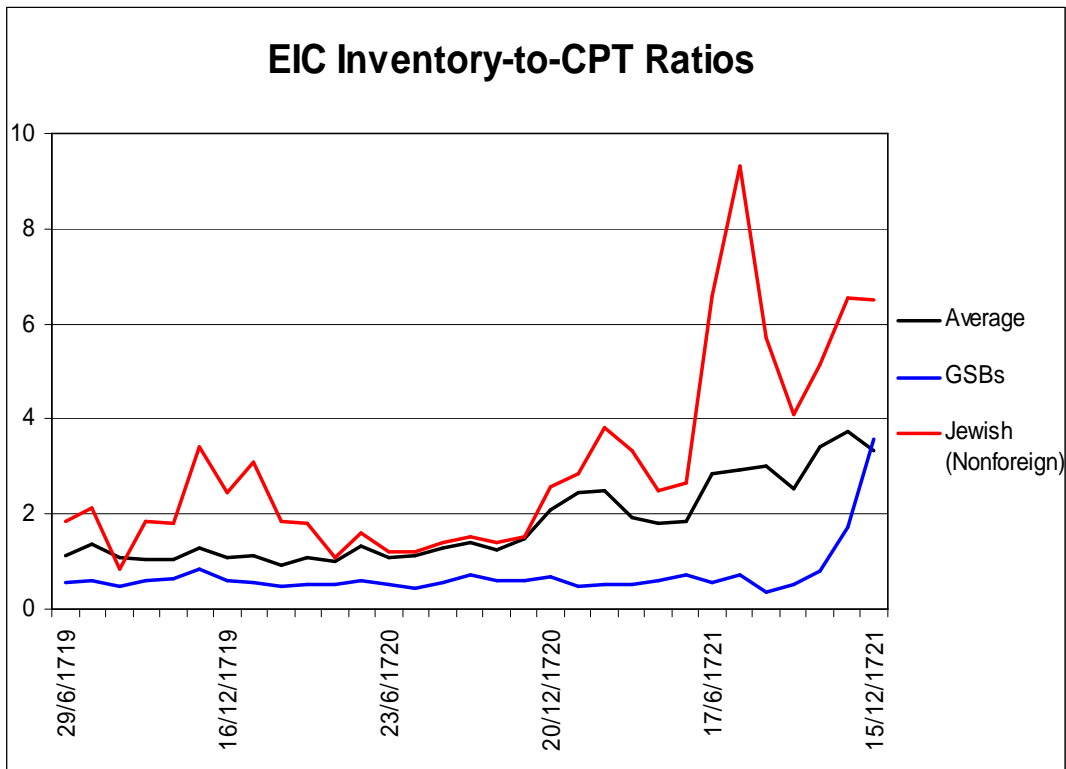
been shown that, in the spring of 1720, PT and CPT were approximately 60 percent of Total Sales, but more than 10 percent of Total Sales generally flowed through the hands of only one or two of the top CPT-traders (Fig. 6). The top CPT-traders were invariably the Swordblade Bank partners Elias Turner for EIC trading and Sir George Caswall for BoE stock trading prior to and during the Bubble. Their dominance, however, vanished by autumn 1720 along with that of many other GSBs who, while not nearly as important as were the Swordblade partners, nevertheless tended to be amongst the top ten or so CPT traders.<sup>14</sup>



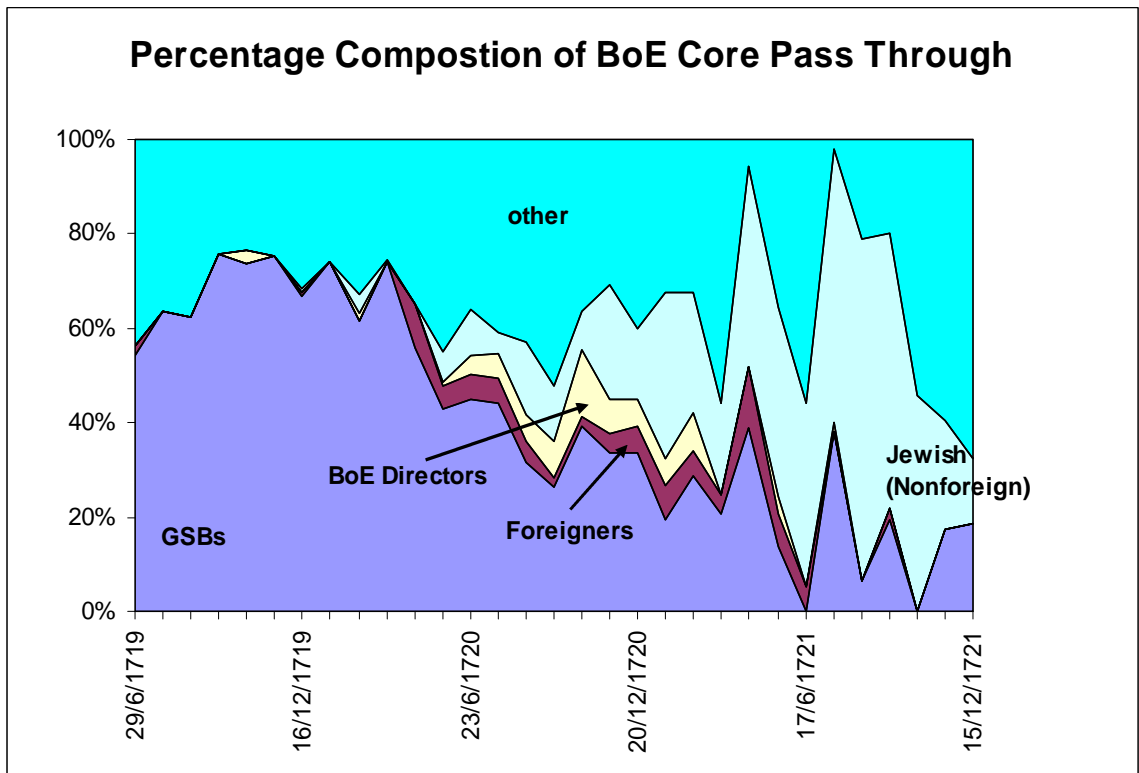
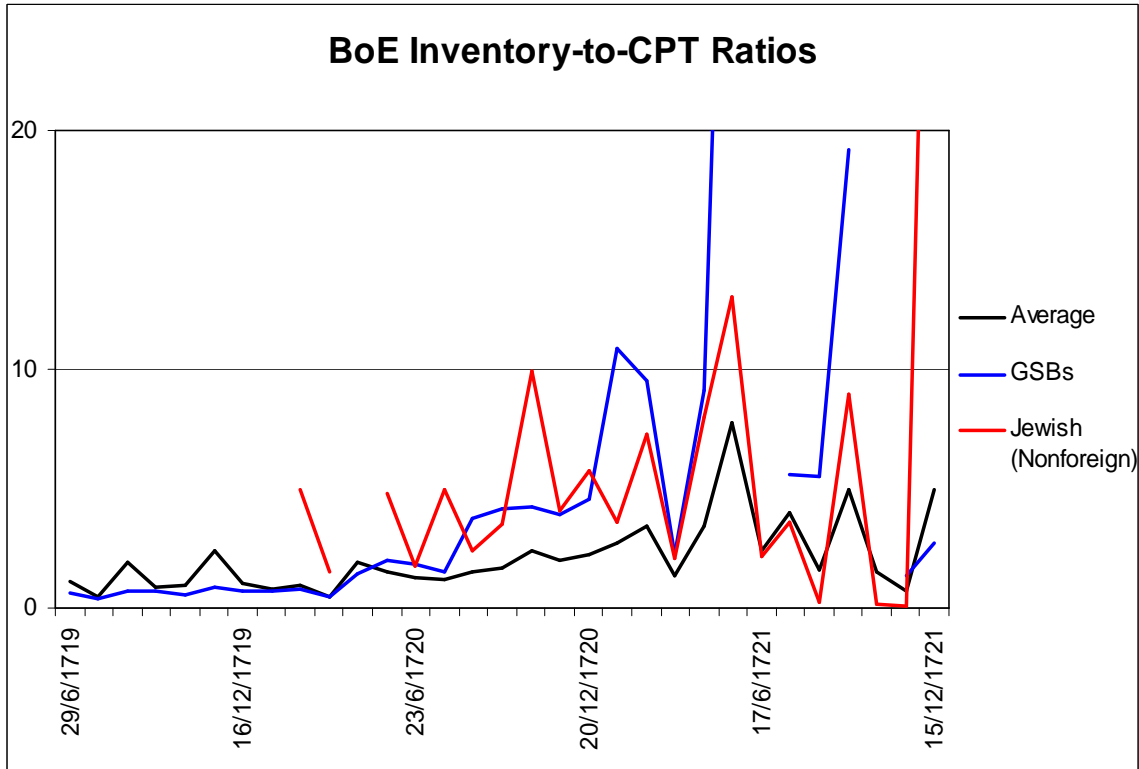
**Fig. 7.** Goldsmith Banker & Broker (GSB) Trade and Inventories of EIC Stock



**Fig. 8.** Goldsmith Banker & Broker (GSB) Trade and Inventories of BoE Stock



**Fig. 9.** Brokerage, dealership and CPT in EIC stock by social affiliation, 1719-21.

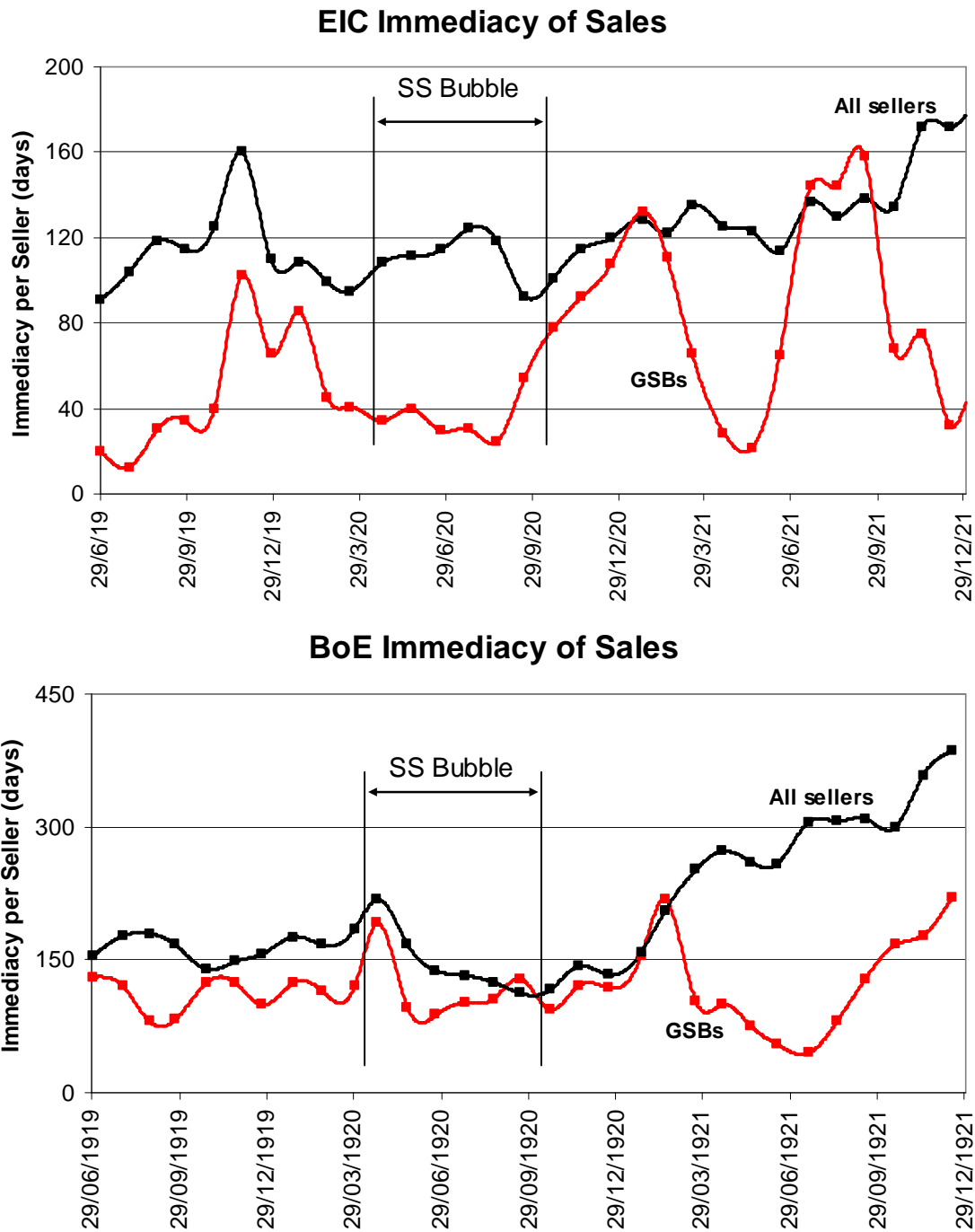


**Fig. 10.** Brokerage, dealership and CPT in BoE stock by social affiliation, 1719-21.

In this section we have established that the GSBs were at the heart of significant changes in intermediation in 1720. Their involvement in total trade and CPT started to decline precipitously before the boom in shares prices was fully underway in the summer of 1720. But at the same time GSBs continued to act like brokers by maintaining small inventories relative to the PT and CPT they facilitated. The distribution of GSB stock inventories was also changing; GSBs moved noticeably out of EIC inventories and into BoE inventories. In the longer term it was the displacement of GSBs as intermediaries that moved the style of intermediation away from brokerage towards dealership. Yet more happened to intermediation than has been described so far. We have yet to generally examine the dynamics of how inventories shifted their locations throughout the trading networks and the speed with which they moved.

## **6. Intermediation and the dynamic behaviour of inventories**

GSBs were acting as brokers and were at the very heart of intermediation. It is not surprising therefore to find them also dominating trends in immediacy of sales. GSB influence in immediacy was especially strong in EIC stock sales during the Bubble (Fig. 11). Overall, immediacy was as strong or stronger during the Bubble than at other times, and the GSB contribution to this is patent in the figure. But after the Bubble and coincident with the large-scale withdrawal of GSBs from share sales, immediacy dramatically deteriorated.



**Fig. 11.** Immediacy of East India Company (EIC) stock sales and Bank of England (BoE) stock sales, 1719-21.

How the GSBs exerted highly immediate brokerage during the Bubble between buyers and sellers of stock is telling. It is embedded within the history of a larger phenomenon – how inventories were distributed between buyers and sellers of stock. To examine the inventory history of buyers and sellers of shares, a tool or method

must first be devised. Imagine two persons who are counterparties in a transfer of shares. A logarithm of the relative inventories of the two would be approximately zero as long as the two inventories were not too different in size. Taking into account that a buyer's inventory of stock can be zero at time of purchase, consider the properties of the following function,  $RINV(t,u,w)$ , of the relative inventories of a buyer ( $w$ ) and a seller ( $u$ ),

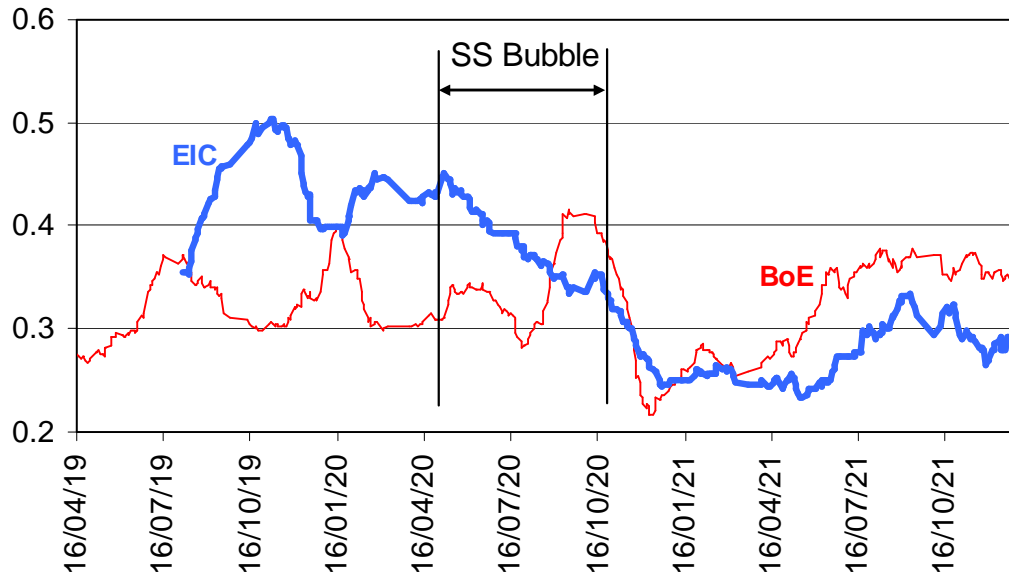
$$RINV(t, u, w) = \log_{10} [1 + I_w(t) / I_u(t)]. \quad (3)$$

If buyers' and sellers' inventories were homogeneously distributed,  $RINV(t,u,w)$  would be expected to be  $\log_{10}(2) = 0.3$  for all  $u$  and  $w$ . We could further imagine that the distributions of inventories could depart from such homogeneity over time, but not be able to do so indefinitely. For example, buyers' inventories could not indefinitely be twice the size of sellers' inventories ( $RINV(t,u,w) = 0.5$ ). Eventually buyers' inventories would have to start to decline relative to sellers' inventories. Thus in the long-term,  $RINV(t,u,w)$  cannot stray far from 0.3, although we cannot be specific as to how far it might be able to stay above or below 0.3 in shorter intervals of time.

In Fig. 12 is illustrated a 90-day moving-average trend for  $RINV(t,u,w)$  for both BoE and EIC stocks. In the figure is also illustrated the 6-month period (end April to end October, 1720) that encompasses the market boom and crash in share prices. Clearly the South Sea Bubble divides our data into two distinct periods in terms of buyers' and sellers' inventory behaviours. Although there appears to be trend at all times, average  $RINV(t,u,w)$  stays much closer to 0.3 after September 1720 than it does in the period before. In the earlier period the deviation from 0.3 is quite marked for EIC relative inventories. What is most striking, however, is that before the Bubble

the trends for BoE and EIC appear to follow a mutual countercycle, whereas after the Bubble the trends co-move with each other. Coincidence in this regard is excluded.

These pre-Bubble trends are dominated by the behaviour of the GSBs.



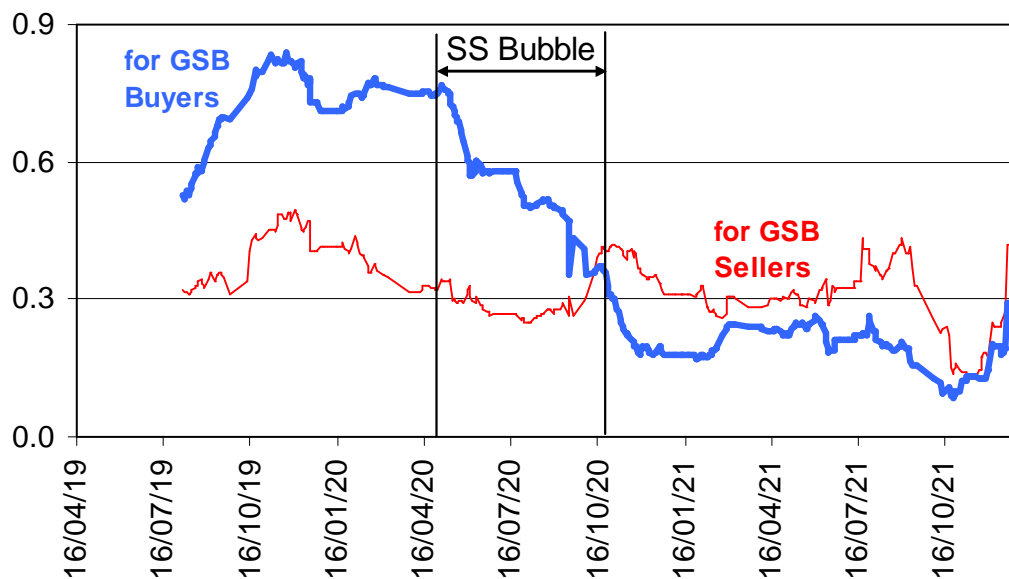
**Fig. 12.** Log-relative buyers' and sellers' inventories for Bank of England (BoE) and East India Company (EIC) stocks, 90-day moving averages, 1719-21.

Prior to the market collapse in September 1720, purchases of EIC stock, as opposed to purchases of BoE stock, were dominated by buyers possessing relatively large inventories. As far as EIC stocks are concerned, Fig. 12 is partially consistent with the usual history of the South Sea Bubble that states that 1720 was a year in which specially inexperienced investors were drawn towards the stock markets. Inexperienced investors would have to buy, by necessity, from people who possessed much larger inventories of stock. GSBs were arguably the most experienced group of investors that can be identified and also were possessed of large inventories.

In Fig. 13 is illustrated the trends in  $RINV(t,u,w)$  for GSB traders as buyers and sellers of EIC stock separately. The figure clearly shows that in the years 1719-21 GSBs sold stock to other individuals (inclusive of other GSBs) who had inventories



generally no larger nor smaller than their own inventories. As buyers of stock prior to the Bubble, however, GSBs behaved quite differently. Their inventories were much larger (up to 7 times larger) than the inventories possessed by persons from whom they purchased stock. The decline in the relative size of their inventories was rapid at the commencement of the Bubble and the decline did not stop until the Bubble itself collapsed. We know that the trends in Fig. 13 are driving the overall EIC inventory trends in Fig. 12 because GSB-trade in this period was such a large percentage of total trade (Fig. 7).<sup>15</sup> Within the middle six months of 1720, at the height of the Bubble and as they disgorged their large inventories, GSBs sold to persons whose inventories of stock were every bit as large as theirs. The recipients of these sales already tended to be EIC shareholders who were about to take over the GSB role as market intermediaries – those foreign and British-resident merchants, largely Jewish, whom we have already identified in Figs. 9 and 10.



**Fig. 13.** Log-relative buyers' and sellers' inventories for East India Company (EIC) stocks, for GSB Buyers and Sellers separately, 90-day moving averages, 1719-21.

<sup>15</sup> We have also affirmed that when Fig. 12 is reproduced, but without GSB participation in buying and selling, the pre-Bubble trends, such as those observed in Fig. 12, disappear.

In this section we have shown that the decline in intermediation services provided by the GSB group came at the end of a period in the GSBs had accumulated large inventories in EIC stock. This was at the start of the stock market boom. GSBs thereafter steadily disgorged their EIC stock inventories, temporarily accumulated inventories in BoE stock, while all the while providing highly immediate brokerage in EIC trade. In both stocks general trade and intermediated trade immediacy was maintained throughout the Bubble and it noticeably deteriorated only after the Bubble and after the demise of the GSBs.

## **7. Conclusions**

Our conclusions are separable into three groups: i) conclusions with respect to network analysis and its adaptability to studies of intermediation.; ii) historical conclusions with respect to the South Sea Bubble and iii) conclusions with respect to how financial economic theorists might approach a model of the South Sea Bubble.

In this paper we have shown that in a flow-network, centrality measures can be defined that are useful for discovering intermediation. If stock trade data can be formed into a flow-network data structure, the network analyst can begin to study how flows in a network are mediated. In our own investigations we have tried to heed the admonitions made by Borgatti (2005), who warned that ‘off-the-shelf’ tools for studying centrality in flow networks are too readily applied to problems for which they are not suited. We recognise that financial intermediation is a centrality concept and requires its own toolkit if it is to be studied using data structured into a flow network. Intermediation occurs across time and entails the intermittent storage of financial securities in the absence of pure brokerage. One of our analytical

innovations has been to translate weighted edges in a directed network into nodal pass-through (PT). It is with PT that other important aspects of intermediation, such as the distinction between brokerage and dealership and the immediacy (speed) of sales, can be analysed. We have also taken the first steps towards the analysis of the components of such networks. By showing how components can be defined in terms of the density with which PT appears in the networks. To this end we have introduced the notion of core pass-through (CPT).

This paper has also made direct contributions to the historian's understanding of the South Sea Bubble. Historians have long known that social and professional affiliations in the stock markets of the early 18<sup>th</sup> Century were important, but their understanding of the effects of affiliation on trade, intermediation and ownership has been far from complete. Historians will not be surprised that goldsmith bankers and brokers (the GSBs), as a social/professional group, dominated intermediation in the markets prior to the Bubble. More surprising, however, is that their importance began to rapidly decline even before the stock market boom of 1720 commenced. Equally surprising is that intermediation was not immediately harmed by the withdrawal of GSBs from the markets. To a large extent a merchant class, much of it Jewish and much of it foreign, stepped in and maintained previous levels of intermediation until the end of 1720. Aided a little by company directors too, these merchant classes operated with higher inventories than did the GSBs. Intermediation in the stock markets thus started to move from brokerage towards dealership.

When modelling a boom or crash, economists will seek, when practical, a decomposition of a boom or crash into "fundamental" and other components. A market fundamental component, for example, can be taken as the valuation that is produced by an acceptable financial pricing model. In such a model a sudden rise in

the assessed riskiness of assets might bring about a crash in their values. Different from such a 'fundamental' crash is a liquidity crash in which sellers are too numerous relative to buyers and intermediation services (liquidity) are inadequate to absorb the order imbalances between sellers and buyers without significant price concessions from the sellers. Our evidence shows that the South Sea Bubble was laden with what the theorist would regard as significant liquidity or intermediation events. The theorist will have to contend first with the documented behaviour of GSBs. Prior to the Bubble there was a build-up of inventories in the relatively risky stock (EIC), a build-up in which GSBs were absorbing EIC stocks from a large number of stock owners who had relatively small stock inventories. These positions in inventories were rapidly unwound during the Bubble, when GSBs drew down their EIC inventories and built up inventories in less risky BoE stock. By the end of the Bubble the GSBs had rid themselves of large inventories in BoE stocks as well. The second event was the demise of the GSBs themselves in trade, a general decline in trade-flow dominance which began before the Bubble. The third event was that intermediation in terms of brokerage and immediacy of sales during the Bubble remained largely as it was prior to the Bubble.

It will thus be difficult to argue that the Bubble's crash in particular was precipitated by a liquidity event, such as a sudden deterioration in immediacy of sales. The evidences for a liquidity boom as a partial explanation of the events in the early summer of 1720 are also problematic, but are more promising as topics for future research. Intermediation in terms of PT and CPT components appeared to be no stronger during the Bubble than it was prior to it, but there is some evidence of an improvement in immediacy of EIC sales (Fig. 11) during the Bubble. An improvement in immediacy would have been inviting to bolder speculators. Temin

and Voth (2004), for example, tell a story how through precocious trading the Hoare's Bank partners were 'riding' the Bubble – a strategy that would have been more hazardous for them than it was without some immediacy in trade. Without some immediacy in trade a speculator would have little assurance that he could quickly sell stocks when needed. Much of the immediacy in trade and brokerage was provided by the GSBs, perhaps in a stampede to leave the markets in relatively risky (EIC) stocks. How an improvement in immediacy might have been connected with the general European credit crisis and the actions of intermediaries prior to the Bubble is the challenge posed to the theorist.

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