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THE BOATS THAT DID NOT SAIL: ASSET PRICE VOLATILITY AND MARKET EFFICIENCY IN A NATURAL EXPERIMENT

Peter Koudijs

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ABSTRACT

What explains short-term fluctuations of stock prices? This paper exploits a natural experiment from the 18th century in which information flows were regularly interrupted for exogenous reasons. English shares were traded on the Amsterdam exchange and news came in on sailboats that were often delayed because of adverse weather conditions. The paper documents that prices responded strongly to boat arrivals, but there was considerable volatility in the absence of news. The evidence suggests that this was largely the result of the revelation of (long-lived) private information and the (transitory) impact of uninformed liquidity trades on intermediaries' risk premia.

Peter Koudijs
Stanford Graduate School of Business
655 Knight Way
Stanford, CA 94305
and NBER
koudijs@stanford.edu

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What drives the short-run volatility of stock returns? Prices move significantly on a day-to-day basis and it is often unclear why. An extensive literature, going back to Schwert (1981, 1989), Roll (1984a, 1988), French and Roll (1986), and Cutler, Poterba, and Summers (1989), offers two possible explanations: (1) the arrival of public news and (2) the impact of the trading process, which can capture privately informed trading, liquidity trades or shifts in investor sentiment.

Distinguishing between these two explanations, however, is not straightforward. Trading and the arrival of news usually go together. Moreover, news arrives continuously to the market and modern textual analysis notwithstanding it is often unclear what information a news item actually contains. It is therefore difficult to identify price movements that are unrelated to the arrival of new information, let alone what such price changes reflect.

The purpose of this paper is to shed more light on what drives short-term asset price movements. Specifically, it uses a natural experiment where information flows are easily observable and where, for exogenous reasons, the market is starved from news for days in a row. The paper aims to (1) identify how much markets move in the presence and absence of news and (2) to explain asset price movements that are unrelated to the arrival of new information.

The natural experiment is provided by the Amsterdam market for English securities in the 18^{th} century. At that time, a number of English securities were traded on the Amsterdam exchange. While the main market for these stocks was in London, Dutch investors held between 20% and 30% of English securities (Bowen (1989), Wright (1999)). This gave rise to active trade in Amsterdam. Importantly, for the periods under study (1771 to 1777 and 1783 to 1787) virtually all relevant information about these securities originated in the

British capital. This information was transmitted to Amsterdam through official mail packet boats that departed twice a week. These were sailing ships, and adverse weather conditions (especially Eastern winds) led to frequent delays and in turn news blackouts in Amsterdam that could last for multiple days. This exogenous variation in the flow of information makes it possible to study stock returns in the absence of news. At the same time, financial markets had long been established and functioned in a way similar to today.

I first document that the Amsterdam market reacted to the arrival of boats from London as one would expect. Prices in Amsterdam responded strongly right after the arrival of news. The variance of stock returns was significantly higher when boats from England arrived. At the same time, volatility in the absence of boats was significant: the ratio of the "no-boat" versus "boat" return variance was between 0.40 and 0.58.

Next, I decompose these asset price movements into their constituent parts. Two factors can explain almost all of the volatility unrelated to the arrival of public news. The first is private information. English packet boats brought in not only public information, but also private signals in the form of trading orders from England. The evidence suggests that these trading orders were spread out over time and affected returns on both days with and days without the arrival of packet boats. As a result, prices in Amsterdam and London moved (slowly) in the same direction, even when there was no direct information sharing. The covariance of returns in London after the departure of a boat and returns in Amsterdam after its arrival provides a measure of the importance of private information.

The second factor that can help explain the volatility not related to the arrival of public news is local liquidity shocks. The evidence suggests that, just as today, liquidity in the market was finite and uninformed trades had (transitory) price impact. This is identified through the covariance of returns within the Amsterdam market.

The estimates indicate that public news explains more than 50% of the return variance on days ships arrived in Amsterdam and around 40% of the overall return variance. Private information explains about 25% and 35% of volatility on days with and without boats, respectively. Liquidity shocks explain up to 30% of the overall return variance for most securities. The exception is the British East India Company, for which liquidity seems to have been particularly good. A large fraction of returns remains unexplained for this security, specifically on no-boat days. This may be an indirect result of the presence of private information. Due to the arrival of private signals from London, adverse selection costs may have been particularly high after the arrival of boats, leading uninformed agents to concentrate their liquidity trades in periods without any boat arrivals (Admati and Pfleiderer (1988)). It is impossible, however, to differentiate this possibility from other explanations that emphasize the importance of sentiment shocks or the divergence of beliefs during periods without recent information from England.

This paper is related to an extensive literature quantifying the impact of news on stock price volatility. Early studies such as Berry and Howe (1994), Mitchell and Mulherin (1994), Andersen, Bollerslev and Cai (2000), and Kalev et al. 2004) generally find a weak relation between the arrival of news and stock market volatility.[1] Recent contributions using textual analysis to identify the impact of different types of news such as Antweiler and Frank (2006), Demers and Vega (2006), Tetlock (2007), Tetlock, Saar-Tsechansky and Macskassy (2008), Griffin, Hirschey and Kelly (2010), Davis, Piger and Sedor (2012), and Boudoukh et al. (2013) find greater explanatory power of news. Studies that analyze weather-sensitive assets, for which it is easier to measure information flows and identify causality, find an important role for public information (Roll (1984a), Fleming, Kirby and Ostdiek (2006), Boudoukh et al. (2007)). Nevertheless, an important fraction of volatility remains unexplained, especially "out of season." Related to this point, Yermack (2014) shows that stocks are less volatile when CEOs are on vacation and news announcements are delayed.

This paper is also related to a literature that examines periods during which information arrives as usual but markets are closed (French and Roll (1986), Barclay, Litzenberger and Warner (1990), Ito and Lin (1992), Ito, Lyons and Melvin 1998)). These studies find that return variance is surprisingly low when trade is restricted. This result suggests that the arrival of news itself is relatively unimportant and that trading activity (capturing privately informed trading, liquidity trades or something else) explains the majority of returns.

In addition, this paper is related to studies on cross-listings, specifically papers that examine how the price of a foreign security is affected when its home market is open or closed. Security prices are more volatile when the home market is open. Nevertheless, a large share of price discovery takes place outside these hours (Harvey and Huang (1991), Forster and George (1995), Werner and Kleidon (1996)). It is unclear whether this is driven by public news originating in the host market or whether this is caused by the trading process.

Relative to this literature, the current paper's main contribution lies in the identification of news flows. In Amsterdam, when no boats arrived, there was no public news from London, and thus no new material public information on English securities. To the best of my knowledge, this paper is the first to analyze a market that continues to operate while public information flows are shut down. This setting provides a unique opportunity to identify the importance of public news, especially since the flow of information (in the form of boat arrivals) is directly observable. In most existing studies it is difficult to know whether all relevant sources of public news have been identified.

It is important to acknowledge that the current paper's setting also has a potential drawback: the mail packet boats could have transmitted more than just public news and private information. In particular, boats conveyed information about London stock prices that, in addition to fundamental information, may have reflected liquidity (or sentiment) shocks. These boats also carried English trading orders that were possibly motivated by the same nonfundamental reasons. Similar to informed trades, these could have been spread out over time. I test extensively for these alternatives and find no evidence that they played an important role. Most importantly, prices in Amsterdam do not appear to have responded to transitory shocks in London.

This paper is also related to a literature that uses historical settings to study asset price volatility (for example Elmendorf, Hirshfeld, and Weil (1996), Silber (2005), Brown, Mulherin, and Weidenmier (2008), particularly studies of the 18$^{\text{th}}$ century securities markets in Amsterdam and London.[2] In seminal work, Neal (1987, 1990) documents that the Amsterdam and London markets were well integrated. Neal relies on daily data for London, but on price data with a frequency of two observations a month for Amsterdam (originally collected by Van Dillen (1931)). Dempster, Wells, and Wills (2000) use Neal's data set to provide more evidence on the integration of the Amsterdam and London capital markets. Harrison (1998) studies the properties of returns in London and Amsterdam (again using Neal's data) and finds that both the shape of the return distributions and the autocorrelation patterns are very similar to those of modern markets. Finally, Koudijs (2014) uses the same historical setting to test the Kyle (1985) model of strategic insider trading, and finds strong evidence in favor of this model. Relative to the above literature on financial markets in the 18^{th} century, this paper is the first (1) to employ data on the arrival of packet boats to measure information flows, and (2) to use Amsterdam price data at a relatively high frequency (that is, three observations a week). Furthermore, this paper goes beyond market integration and general characteristics of the return process to identify the deeper sources of asset price volatility.

The paper proceeds as follows. Section I provides historical background and summary statistics. Section II presents two examples of the paper's approach. Section III evaluates whether all relevant information originated in England, and whether packet boats conveyed material information as opposed to transitory shocks to liquidity of sentiment. In Section IV I present baseline estimates of the return variance in periods with and without the arrival of a boat. I then discuss potential explanations for volatility in the absence of news, in particular private information and local liquidity shocks, and quantify their impact. Section V concludes. Additional information and results are presented in the online Appendix.[3]

I. Data and Historical Background

In this section I first describe the Amsterdam market itself: how developed was it, and to what extent can it serve as a useful comparison for markets today? Next, I summarize how news was transmitted between London and Amsterdam. Third, I discuss the assets that were traded and the price data that are available. Finally, I provide a number of descriptive statistics.

A. Market Structure

Amsterdam and London were the most important securities markets in the 18^{th} century. The Dutch started to invest in English securities in the early 1700s (Wilson (1941)), as doing so provided a good opportunity to diversify domestic portfolios at relatively low cost.[4] Unlike today's Anglodutch "Siamese twins," the English securities traded on both sides of the North Sea were identical. The historical record indicates that there was active trade in English securities on the Amsterdam exchange (Van Dillen (1931), Van Nierop (1931), Wilson (1941)). Although volume data are unavailable for the period, some inferences can be made about the size of the market for English stocks in Amsterdam. Bowen (1989) and Wright (1999) show that during the 1770s around one-third of the shares of British companies were in the hands of Dutch investors. During the 1780s this fell to around one-fifth.

The Amsterdam market was organized in a way similar to today. Trade took place in a centralized location. Around noon two official trading hours were held in the entrance hall of the Exchange building (Spooner (1983), Hoes (1986)).[5] There were no official market makers. Trade was based on limit orders; a group of approximately 40 official brokers (and an unknown number of unofficial brokers) convened to execute as many of their principals' orders as possible. Regulation prohibited these brokers from trading on their own account (Smith (1919), Van Nierop (1931)). At the end of the afternoon, a committee of so-called sworn brokers reported the going price of the day (Smith (1919), p. 109). Investors used this information to monitor their brokers ex post (Polak (1924), Hoes (1986)).

Apart from spot trade, a large fraction of trading activity was related to futures and options. Derivatives were introduced in the 17^{th} century and their use and trade was fully institutionalized (Petram (2011)). Futures were actively used for shorting.[6] Every three months, future and option positions were cleared during periods of "rescontre" (Van Dillen (1931)). There were no formal margin requirements and the market was mainly based on reputation.

Similar to today, there was a developed market for margin loans. This system had been developed in the early 17th century (Gelderblom and Jonker (2004)) and was actively used in the 18th century to fund (spot) positions in the English securities (Smith (1919); Wilson (1941)). These margin loans usually ran for six months and had margin requirements. The legal terms of the contracts are broadly similar to today (Koudijs and Voth (2014)).

The historical evidence suggests that the sophistication of market participants was considerable. Temin and Voth (2004) document investor strategies during the South Sea bubble of 1720 that were very similar to those observed during the recent tech bubble. Frehen, Goetzmann and Rouwenhorst (2013) suggest that in 1720, market participants were perfectly able to differentiate between systematic and idiosyncratic risk.

B. News Flows

How did news from England reach Amsterdam? Since 1660, England and the Dutch Republic had been connected through a system of sailing ships between Harwich (England) and Hellevoetsluis (Dutch Republic), an important harbor close to Rotterdam. These packet boats were specifically designed for the route and ensured a swift and regular flow of information between the two countries. Since Amsterdam did not have a direct connection with the North Sea (boats had to sail past the island Texel), this was the fastest way information from London could reach Amsterdam (Hemmeon (1912), Stitt Dibden (1965), Ten Brink

(1969)).[7]

The packet boats were scheduled to leave Harwich on Wednesdays and Saturdays. The median sailing time was two days (including the day of departure). It took additional time to carry the news over land. Roads were particularly bad and rivers had to be crossed by ferry. Even though the news was carried on horseback, transport from London to Harwich and from Hellevoetsluis to Amsterdam added two days to the total travel time, making a total of four days (including the day of departure). Section I of the Internet Appendix has more details.

The packet ships often encountered adverse winds and as a result news could be significantly delayed for days, sometimes even weeks. Around a third of the crossings from England to Holland were delayed. During such periods of bad weather no news could be transmitted across the North Sea. Indeed, the *Tatler*, an English newspaper of the time, noted that there could be a news blackout in London "when a West wind blows [...], keeping news on the other side of the Channel" (quoted in Dale (2004), p. 17). The same was true for Amsterdam when the wind was blowing from the east.

The packet boat system was the main channel through which news from England reached investors in Amsterdam. The Dutch newspapers of the time all relied on the packet boat service to receive news from England. All articles with new information from London can be traced to the arrival of a specific packet boat. During periods of particularly bad weather, news from England would arrive in Amsterdam through the harbor of Ostend in today's Belgium, which had a regular packet boat service with Dover in England. This occurred nine times during the sample periods. The Dutch newspapers meticulously reported these episodes, which allows me to take them into account in the empirical analysis.

The packet boat system was also the main channel for private letters. This is borne out by the English correspondence from Hope & Co. during the sample periods. One of the biggest Dutch banking houses of the period, Hope had strong connections in England and was active in the stock market. All correspondence with their English counterparties took place through the packet boat system (see Section I in the Internet Appendix for details). Thus, important individuals received (public) news at the same time as the market as a whole. Even Nathan Rothschild, who famously was the first in London to receive news about the outcome of the Battle of Waterloo in 1815, received this information only a few hours before the general public (Dale (2004), p. 17).[8]

What was the content of the news transmitted from London to Amsterdam? Investors in Amsterdam received all public information available to English investors, as each packet boat brought newspapers and other newsletters that contained information about recent developments in London, including the most recent security prices. The packet boats also brought private letters from London correspondents.[9]

C. Data, Sample Period, Sources, and Descriptive Statistics

I examine all English securities cross-listed in London and Amsterdam for which frequent price data are available for the Dutch market. This includes three stocks and two government debt issues: the British East India Company (EIC), the Bank of England (BoE), the South Sea Company (SSC), and 3% and 4% annuities. The three companies were involved in a number of business activities. The EIC was a trading company that held large possessions in India. The company's prospects were determined by conditions in the East and political developments in England (Sutherland (1952)). Both the BoE, which wasn't a central bank yet, and the SSC helped finance the British government debt.[10] The BoE also provided large-scale credit to the EIC and discounted commercial bills (Clapham (1944)).

I focus on two periods: September 1771 to December 1777, and September 1783 to March 1787. These periods represent the intersection of two sets: (1) periods for which all relevant information is available in the historical sources, and (2) periods of peace on the European continent, with an absence of severe financial crises. The latter consideration ensures that important information about the English stocks originated in England – an important condition for the clean identification of news arrival. The starting point of the first period, September 1771, is determined by data limitations. This period ends in December 1777, a few months before tensions between England and France increased, leading to a declaration of war in March 1778.[11] In 1780 war also broke out between the Dutch Republic and England.[12] The second sample period starts in September 1783, right after the signing of an official peace treaty between France and England and a preliminary peace treaty between England and the Dutch Republic. This sample period ends in March 1787. Domestic tensions in the Netherlands increased in April 1787 (on April 24 there was a dramatic change in city government in Amsterdam), eventually leading to domestic conflict in May 1787 and an intervention by the Prussian army in September 1787.

Amsterdam price data are hand-collected for the entire period between September 1771 and March 1787 and come from the *Amsterdamsche Courant*, and where necessary are supplemented by information from the *Opregte Haerlemsche Courant*). For each stock, these data contain three observations per week (Monday, Wednesday and Friday). London price data, available at a daily frequency for the EIC, BoE, and 3% annuities, come from Neal (1990), and necessary are supplemented with data from Rogers (1902).[13] In both Amsterdam and London, prices are reported in Pound Sterling (normalized as a percentage of the nominal or par value). Returns are adjusted for dividend or coupon payments. Information on dividends comes from Clapham (1944) and Bowen (2007), and information about ex-dividend and ex-coupon dates comes from Rogers (1902) and the *Amsterdamsche Courant*.

London prices refer to spot transactions. By the second half of the 18$^{\text{th}}$ century, a significant fraction of trade in the English stocks in Amsterdam was concentrated in the futures market (Van Dillen (1931)). As a result, all available price data for the Amsterdam market refer to futures prices. To facilitate comparison between London and Amsterdam, I convert all Amsterdam future prices into spot prices, using a fixed cost-to-carry rate. See Section I of the Internet Appendix for details. A future contract had four possible expiration dates: February 15, May 15, August 15, and November 15. The newspaper reported prices for the future contract ending on the nearest date. This means that the maturity of a future contract was never longer than three months. It is unlikely that fluctuations in the short-term interest rate contributed significantly to the volatility of returns. For example, an instantaneous increase in the cost-to-carry rate of 100 bps would lead to a log return of 0.05% (0.10%) on a future contract with a median (maximum) maturity of 1.5 (3) months – this is at the 6$^{\text{th}}$ (21$^{\text{st}}$) percentile of the distribution of absolute EIC returns meaning that 94% (79%) of returns were larger in size. Furthermore, results in Section V.B of the Internet Appendix indicate that price changes of futures with a longer time to maturity (for which changes in the cost-to-carry rate should be more important) were not more volatile.

Data about boat arrivals in the Dutch Republic come from the *Rotterdamsche Courant* (see Section I of the Internet Appendix). The sailing schedule allowed for two boat crossings a week. Arrival data in England were hand collected from several English newspapers:

General Evening Post, Lloyd's Evening Post, Lloyd's Lists, London Chronicle, and *Middlesex Journal.* Due to the time-intensive nature of this part of the data collection process, I only collected this information for the two periods of interest.

Table I reports descriptive statistics for the Amsterdam market. Panel A provides information on returns between 1771 to 1787, both inclusive and exclusive of the war period between 1778 and 1783. There are three prices a week for the Amsterdam market (Monday, Wednesday, and Friday). I calculate percentage log returns over two-day (Monday-to-Wednesday and Wednesday-to-Friday) or three-day periods (Friday-to-Monday), indexed by subscript t, using $\Delta p_t^{AMS} = 100 * \log(p_t/p_{t-1})$.[14] The results show that the return variance between 1771 and 1777 and 1783 and 1787 is considerably lower than during the 1771 to 1787 period as a whole. The difference is statistically significant and reflects the fact that security prices were highly volatile during the war period. The exception is the EIC, for which the difference between return variances is relatively small. For comparison, Panel B provides information for the entire 1723 to 1794 period, for which Amsterdam security prices are available roughly every two weeks (Van Dillen (1931)). In particular, Panel B reports the variance in two-week returns for 1771 to 1777 and 1783 to 1787, and the full period. The results suggest that the two sample periods are largely representative of the 18$^{\text{th}}$ century as a whole.[15] For the BoE and 3% annuities, the return variance is roughly the same. For the EIC, the return variance is somewhat higher during the sample periods.

[Table I about here]

Panel C focuses on the boat arrival data. These data can be divided in subperiods based on the arrival of boats. During the two sample periods, there were 681 such between-boat periods, more than half of which were long enough that, in addition to a price observation reflecting an incoming boat, there was also a price observation that did not reflect the arrival of English news. The median length of a between-boat period is three days, but the distribution has a fat right tail. The 95^{th} percentile is seven days and the maximum is 21 days. The maximum number of price observations per period is eight.

II. Examples

Figure 1 illustrates the paper's approach with two concrete examples. Panel A illustrates how public information was transmitted. On November 18, 1783, English Prime Minister Fox declared that the British East India Company's (EIC) finances were in a "deplorable state" (Sutherland (1952), p. 375)[16] and the company's stock price in London fell dramatically from 136 to 120. The vertical/diagonal black lines in the figure indicate how and when the packet boats transmitted this news to Amsterdam. In the days following the decline on the English exchange, weather conditions were unfavorable and the packet boat could not cross the North Sea. As a result, prices in Amsterdam did not adjust. After wind conditions improved, a packet boat reached the Dutch Republic on November 28, 10 days after Fox gave his speech. Prices in Amsterdam fell sharply in response.

[Figure 1 about here]

Panel B illustrates the importance of private signals and factors unrelated to new information. During the winter of 1775 to 1776 weather conditions were particularly unfavorable, and thus news from England reached Amsterdam with long intervals. This period fell in the middle of the American Revolution, and on December 27 an envoy arrived in London with secret dispatches from the Revolutionaries, report of which reached Amsterdam on January 2. Over the subsequent two weeks there was a news blackout in Amsterdam due to especially strong eastern winds.[17] When, on January 15, the English news (dated January 4) finally arrived, it only contained rumors: the contents of the American dispatches had not been disclosed yet. At the same time, the London EIC stock price had increased from 165.75 to 167.75. Interestingly, the EIC price in Amsterdam had gone up as well during the blackout. Later, it turned out that the American dispatches contained a serious peace proposal – potentially good news for the EIC. It is possible that privately informed agents traded on this information in both markets, causing prices to go up. The figure suggests that such private information was not incorporated into prices right away.

After January 4, prices in London fell in response to the news that the English were not prepared to accept the American terms for peace. Then, on January 11, the London EIC price rose from 166.5 to 168.5 for no apparent reason. When Amsterdam learned of this on January 23, the market only partially responded. In the subsequent blackout period that lasted more than two weeks, the Amsterdam EIC price fell from 167.25 to 166.75, only to recover to its previous level after the arrival of English news on February 7. The factors driving these price movements were probably unrelated to information and may have reflected liquidity shocks or changes in sentiment.

III. Validation Experiment

Before turning to the paper's main results, in this section I discuss the historical setting in greater detail. First, I take a closer look at the direction of news flows. I examine whether relevant information about the English securities originated in England. Next, I provide evidence that the packet boats carried material information that moved stock prices. The results suggests that the transmission of transitory liquidity shocks was less important.

Finally, I provide suggestive evidence that trading volume on no-boat days was considerable.

A. Direction of News

The identification strategy of this paper relies on the assumption that relevant information about the English stocks originated in England. While I focus on two sample periods for which this is likely the case, ultimately whether this assumption is correct is an empirical question. To shed light on this question, I first analyze the flow of information between London and Amsterdam using a simple econometric framework that takes into account variation in communication lags and the discrete arrival of the packet boats. Figure 2 illustrates this approach. As noted above, log returns in Amsterdam are calculated over two- or three-day periods that are indexed by t. Those returns reflect either the arrival of a packet boat ($\Delta p_t^{AMS,boat}$) or no arrival of a boat ($\Delta p_{t+d}^{AMS,no-boat}$). There can be multiple "no-boat" returns between the arrival of two ships; this is indicated by d. Table I shows that there are at most seven no-boat returns per between-boat period and thus $d \in [1, 7]$. With the arrival of a boat, market participants in Amsterdam observed the change in the London price since the last boat departure, which captures (possibly among other things) all new information that reached the London market during this between-boat period. This price change is given by Δp_{s-1}^{LND}, where s stands for a specific period between two boat departures. London returns, Δp_t^{LND}, are calculated over the same two- or three-day periods. $\Delta p_t^{LND,boat}$ reflects the arrival of a boat from Amsterdam, and the Amsterdam return transmitted by this boat is given by Δp_{s-1}^{AMS}.

[Figure 2 about here]

Following the above return definitions, I estimate

$$\Delta p_t^{AMS,boat} = \alpha_0 + \alpha_1 \Delta p_{s-1}^{LND} + \Delta p_{s-2}^{AMS} + u_t$$

$$\Delta p_t^{LND,boat} = \beta_0 + \beta_1 \Delta p_{s-1}^{AMS} + \Delta p_{s-2}^{LND} + v_t,$$

where the coefficients α_1 and β_1 capture the response of Amsterdam and London, respectively, to price changes in the other market between boat departures. These price changes also respond to past returns from the other market. To reduce attenuation bias, I include these past returns in the regressions; with a slight abuse of notation these are denoted by Δp_{s-2}^{AMS} and Δp_{s-2}^{LND}.

Table II presents the results. Since detailed London price data are available only for the EIC, BoE and 3% annuities, results are available only for these three securities. The table shows that London price changes had strong explanatory power for prices in Amsterdam. There is some evidence for an effect in the other direction as well, but the R^2s are virtually zero, and the coefficients are seven to eight times smaller and only borderline statistically significant (for the BoE, the coefficient is insignificant altogether). These results confirm that, at least for the paper's specific sample periods, most relevant new information originated in London.

[Table II about here]

Next, I perform a similar analysis using a vector error correction model (VECM). The advantage of a VECM is that it explicitly takes into account that Amsterdam and London prices were co-integrated. The disadvantage of this approach is that one cannot account for the variation in lag lengths and the discrete arrival of boats. Details on the estimation and impulse response functions are presented in Section II of the Internet Appendix. The results again show that innovations in prices in London have strong predictive power for Amsterdam returns, not the other way around. Since the VECM estimates do not rely on actual boat arrivals, I can also perform this analysis for the period of international conflict between January 1778 and August 1783, during which time information on boat arrivals is not available. Not surprisingly, for this period there is strong evidence that price changes in Amsterdam had an important effect on prices in London. The results are summarized in Table III in the form of Hasbrouck (1995) information shares. During the two sample periods characterized by peace, between 92% and 99% of relevant information originated in London. For the intermediate period characterized by international conflict, this drops to between 58% and 77 %. This result highlights the importance of restricting the paper's main analysis to the 1771 to 1777 and 1783 to 1787 periods.

[Table III about here]

I also test whether returns on English securities in Amsterdam are related to fluctuations in the price of Dutch securities. Changes in general economic conditions in the Netherlands, such as movements in the interest rate, should have affected both Dutch and English securities. Table IV presents results from the regression

$$\Delta p_t^{AMS,no-boat} = \alpha_0 + \alpha_1 \Delta \overline{AMS}_t + u_t,$$

where $\overline{AMS}$ is a vector of percentage log returns on three Dutch securities: VOC (Dutch East India Company), WIC (Dutch West Indies Company) and bank money. Two different currencies circulated in Amsterdam: cash and bank money, which represented current accounts at the Bank of Amsterdam (Quinn and Roberds (2007)). Fluctuations in the exchange rate between these two "types" of money might convey information about aggregate risk aversion, investment opportunities, and the availability of liquidity.[18]. I estimate the equation above for days without boat arrivals. The results show that there is virtually no correlation between English and Dutch assets on days without news. Returns on VOC stock have some predictive power, but the coefficients are small and statistically insignificant. An exception is the BoE, for which the (economically small) coefficient is marginally statistically significant. The corresponding R^2s are close to zero. These results confirm that general economic conditions in the Netherlands had limited impact on the pricing of the English securities.

[Table IV about here]

In Sections III.A and III.B of the Internet Appendix I examine whether relevant news from England could have arrived through other channels, specifically, other types of ships or carrier pigeons. The evidence suggests that these channels did not play an important role. In Section III.C of the Internet Appendix I investigate whether relevant news could have originated in a third place, like France, the U.S., or the East Indies. The results suggest that news from Paris played only a limited role, and that relevant information from the U.S. and the East Indies reached London, before being transmitted to Amsterdam. In Section IV of the Internet Appendix I use an instrumental variables approach to examine whether the arrival of news might have been endogenous to developments in the stock market (or economic conditions in general). The evidence suggests that this is not the case.

B. Boat Arrivals and News

To what degree did the arrival of a packet boat result in the transmission of actual news? Following Cutler, Poterba, and Summers (1989) and Fair (2002), in Section V.C of the Internet Appendix I analyze the 25 largest returns on EIC stock and the 3% annuities (as a representative of the other four government related securities).[19] In both cases, 22 of the 25 largest returns occurred following the arrival of a packet boat. For the EIC, the arrival of a boat coincided with the transmission of relevant information in 20 cases. This information contained news about, for example, significant events in India or decisions in Parliament affecting the company. For the 3% annuities a boat arrival resulted in the transmission of material information in 21 of the 22 cases, reflecting news about the national debt, developments in the U.S. revolutionary war, or the situation in Ireland. For the largest returns, the most important drivers of the variance estimates, there seems to be a close link between the arrival of a boat and the transmission of relevant information.

Next, I examine the general relation between the return variance and specific news content. As there were no formal disclosure requirements, it is impossible to isolate events such as earnings announcements. In addition, no press specialized in publicly traded companies. The only English security frequently mentioned in the Dutch newspapers was the EIC. I test whether the Amsterdam stock price moved more when the EIC was mentioned in the press. In addition, I interact the mentioning of the EIC with three sets of keywords that were potentially relevant for the company: (1) financial terms such as "dividends" or "capital," (2) geographic locations or relevant persons in the East Indies, and (3) references to the Cape (of Good Hope) Colony, as ships arriving from India would dock at the Cape to allow the crew to recover and a regular news service with England transmitted the most recent news brought in by these ships.

Note that the quality of the printed copy is not good enough to apply machine reading techniques to the full text of the news articles. However, one Dutch newspaper, the *Leydse Courant*, capitalized keywords during the 1771 to 1778 period to signal the topics covered, and it is feasible to impute those by hand. To verify that the capitalization of keywords in the *Leydse Courant* does not reflect something other than the actual topics covered, I include a fourth category of words that signal (stale) background information rather than breaking news (words such as "declarations" or "proclamations"). Section V.C of the Internet Appendix provides more details on the different news categories.

Table V presents the results. Column (1) shows that a reference to the EIC is associated with higher return volatility, especially if it is mentioned more than once.[20] In the 28 instances in which the EIC was mentioned at least twice, the return variance was more than three times higher than the benchmark. As a comparison, this is at the 75$^{\text{th}}$ percentile of news to no-news ratios estimated for modern securities (Boudoukh et al. (2013)). Financial terminology and references to the Cape are associated with return variance that is about 2.5 times higher than the benchmark, although only the former is statistically significant. There is no relation with the mentioning of the East Indies. Words signaling background information are associated with significantly lower volatility. It is likely that, due to space limitations, this information was published only when there was no other news fit to print. The adjusted R^2 of the regression is 0.05. This is about as high as what Griffin, Hirschey, and Kelly (2010) find for developed countries using modern data.

In columns (2) to (6) I interact the different news components with the EIC news dummies to unpack the effects. Column (2) shows that if an article uses financial terminology and contains more than one reference to the EIC, the return variance increases substantially. This effect, though (borderline) statistically insignificant and based on a limited number of observations, almost fully explains the predictive power of the financial terminology dummy and one-third of the *EIC (>1)* dummy. Column (3) indicates that the interaction with the *India* dummy is not associated with higher volatility. Column (4) shows that there is a large and statistically significant interaction effect between the *EIC (>1)* and *Cape* dummies (again based on a limited number of observations). This fully explains the predictive power of the *Cape* dummy and about a third of the effect of the *EIC (>1)* dummy. Column (5) shows that references to the EIC are not associated with higher volatility if they are accompanied by background stories. The specification in Column (6) includes all interaction terms together and has an adjusted R^2 of 0.11 (0.08 if estimated on absolute rather than squared returns). In sum, I find a statistically significant relation between the arrival of certain types of news and EIC returns.

[Table V about here]

C. Boat Arrivals and Transitory Shocks

The above results confirm that the packet boats transmitted relevant information about the English securities. It is of course possible that in addition to this news, the boats also transmitted English trading orders that affected volatility in Amsterdam. Suppose, for instance, that a party in London wanted to sell (or buy) for uninformed liquidity reasons.[21] Suppose further that this trade had a (transitory) price impact (Grossman and Miller (1988)). Then it is possible that the London agent executed part of his orders in Amsterdam, or that the price impact he caused in London was transmitted to Amsterdam through arbitrage.

I evaluate the impact of English liquidity shocks in two ways. First, I test whether Dutch liquidity shocks affect prices in England. The Dutch held between 20% and 30% of the English securities, and unless arbitrage worked in a dramatically different way, Dutch liquidity shocks should have affected prices in England in a similar way. To test this conjecture, I compute the variance of security returns in London on days with or without boat arrivals from Amsterdam. The results, reported in Secion V.D of the Internet Appendix, show no significant difference. If anything, volatility is lower on days with news from Amsterdam.

Second, I use the fact liquidity shocks are transitory and revert over time (Hendershott and Seasholes (2007), Duffie (2010), Tetlock (2010), Nagel (2012)). If liquidity shocks were transmitted from London to Amsterdam (having a transitory price impact in both markets) we would expect London returns to predict subsequent reversals in Amsterdam. To test this conjecture, I run the following regression:

$$\Delta p_{t+T}^{AMS} = \alpha_0 + \alpha_1 \Delta p_{s-1}^{LND} + \varepsilon_t,$$

where Δp_{s-1}^{LND} is the London return observed in Amsterdam at time t, and Δp_{t+T}^{AMS} is the subsequent Amsterdam return over period T, where T ranges from two or three days to four weeks (estimates for longer horizons yield similar conclusions). This period excludes the immediate response to news from London (see Figure 2). Tables VI to VIII, Panels B report the results. Note that the results are restricted to the EIC, BoE and 3% annuities, the only securities for which frequent price data in London are available. None of these three stocks exhibit (negative) predictability *across* markets over any of the time horizons considered.

This suggests that liquidity shocks (or any other sort of transitory price changes) were not transmitted from London to Amsterdam.

The above statistical tests may have limited power. It is ex ante unclear over what horizon returns should revert and the slow execution of liquidity trades could lead to momentum in the short run, attenuating the reversal estimates. For comparison, Panels A and C of Tables VI to VIII present estimates of predictability *within* the Amsterdam and London markets. For the BoE and 3% annuities, there is evidence of within-market reversals for up to one week. This result suggests that the tests for reversals have reasonable power. The reversal estimates are surprisingly similar in magnitude to modern estimates (Tetlock (2010), Table 1 reports a coefficient of around -0.10). There is no evidence of reversal in EIC returns.

[Tables VI to VIII about here]

These findings seem inconsistent: if it was possible to arbitrage between markets, why did liquidity shocks only have an impact in the home market? The answer lies in the fact that, due to communication delays, arbitrage was imperfect. It took at least seven days (the duration of a round trip) to complete an arbitrage operation. If liquidity shocks affecting one market were expected to revert within this period (as suggested by the results in Tables VI to VIII), they should not have affected the other market. Moreover, arbitrage was risky as prices could change significantly within a week. To illustrate these points, in Section V.E of the Internet Appendix I examine the distributions of price differences between London and Amsterdam. The results indicate that price differences narrowed after the arrival of a boat (more mass around zero) but remained significant. In summary, although it is possible that English (uninformed) order flow occasionally affected returns in Amsterdam after the arrival of a boat, the empirical results indicate that in general the effect was small.

D. *Transaction Data*

It is possible that investors in Amsterdam traded significantly less on days without news. This would imply that liquidity was significantly lower on days without news and that minor order flow imbalances could have led to large price reactions. While volume data for this period are not available to test this conjecture, detailed information is available for a small sample of transactions in the Amsterdam market, roughly equally divided between EIC, BoE and SSC stock and the 3% annuities.[22] Of the 32 total transactions, only four transactions, or 12.5%, took place on days with news (9% when value weighted). The average transaction size of $\sim$ £1,500 translates into £150,000 in today's money. On average, news from London reached Amsterdam two times a week. If market participants were indifferent between trading on days with or without news, we would expect that on average 28.6% of transactions would take place on days with news. This means that there seems to have been a tendency to trade on days without news. The difference between these percentages is significant, with a p-value of 0.028 (based on a binomial distribution and a one-sided test).

IV. Explaining Volatility in The Absence of News

A. *Baseline Estimates*

The results in Table II reveal that Amsterdam responded very strongly to returns in London after the arrival of a boat. How big was the impact of these boat arrivals on the volatility of English security returns in Amsterdam? In Section V.F of the Internet Appendix I present the kernel densities of boat and no-boat returns for the five English securities.[23] The figures clearly show that returns are more volatile after the arrival of new information.

The distribution of news returns has considerably more mass in the tails.

Table IX presents the first four moments of the return distributions for periods with ($B_t = 1$) and without ($B_t = 0$) a boat arrival. Importantly, the variance of returns is higher after the arrival of a boat. This results holds for all five securities. In addition, the fraction of zero returns is significantly higher during no-boat periods. The ratio of return variances $var\left(\Delta p_{t+d}^{AMS,no-boat}\right)/var\left(\Delta p_t^{AMS,boat}\right)$, is between 0.40 and 0.58 (depending on the security) and is statistically significantly different from one.[24] Average returns are considerably higher during periods with a boat arrival, especially for the EIC. This result is consistent with boat returns being more volatile and thus more risky. The difference in returns is not statistically significant, however.

[Table IX about here]

The volatility of returns in the absence of boats did not depend on whether a no-boat period was expected. On average there were two boat crossings a week and three price observations. This means that many no-boat periods were expected. Results in Section III.A of the Internet Appendix indicate that volatility was no different if the absence of a boat was not anticipated.[25] In Section V.G of the Internet Appendix, I examine whether returns in the absence of boats were more volatile if the most recent news from London was relatively old. This could potentially reflect aversion to ambiguity. This is not the case. Average returns did not differ significantly.

B. Roadmap

What can explain the volatility in the absence of news? The remainder of this section discusses three possible explanations: delayed response to public news, privately informed trading, and local liquidity shocks. Before turning to the tests, I briefly discuss how these different alternatives can be identified.

To test for the delayed response to public news, I examine the time series properties of returns in Amsterdam.[26] A slow response to news is usually associated with initial under-reaction, followed by return continuation or momentum (Hong and Stein (1999)). Private information is identified by the covariance of returns in Amsterdam with contemporaneous (but as-of-yet unreported) price changes in London *after* the departure of a boat. Similar to the example in Figure 1, Panel B, the idea is that private information caused Amsterdam and London prices to (slowly) move in the same direction, even when there was no direct information sharing. Finally, I use the covariance of returns within Amsterdam to identify the (transitory) impact of local liquidity shocks.

This section also introduces a simple framework to quantify the effect of these different factors on the volatility of stock returns. I analyze both days with and without the arrival of boats. In this decomposition the immediate response to public news on news days, measured by the covariance between returns in London *before* the departure of a boat and price changes in Amsterdam after its arrival, plays an important role. Table X provides a brief overview of the (potentially) relevant factors. Public news, private information, and local liquidity shocks can explain virtually all variation in security returns for all but the EIC, for which a large fraction of no-boat returns remains unexplained. To investigate this further, I take a closer look at the patterns of return reversals.

[Table X about here]

C. Slow Response to Public News

It is not straightforward to identify a slow response to news through return continuation. In the presence of liquidity shocks returns, will also have a tendency to revert. Simple autocorrelation coefficients aggregate the two effects, potentially cancelling them out. A solution to this problem is to differentiate between the continuation (or reversal) of past London and Amsterdam returns, where the former approximates news shocks and the latter picks up liquidity shocks. More specifically, I conduct the following test. For all returns in Amsterdam I determine whether a boat arrived from London during the previous period ($B_{t-1} = 0, 1$). For the cases in which $B_{t-1} = 1$, I estimate

$$\Delta p_t^{AMS} = \alpha_0 + \alpha_1 \Delta p_{t-1}^{AMS,boat} + \alpha_2 \Delta p_{s-2}^{LND} + \varepsilon_t \text{ if } B_{t-1} = 1, \qquad (1)$$

where Δp_t^{AMS} can reflect the arrival of a boat or not, $\Delta p_{t-1}^{AMS,boat}$ is the Amsterdam news return over period $t-1$, and Δp_{s-2}^{LND} (with a slight abuse of notation) is the London news return observed in Amsterdam during the preceding period. The coefficient α_1 measures reversals of news returns in Amsterdam. A slow response to news from London implies that $\alpha_2 > 0$.[27]

Table XI presents the regression results. Because London price data only cover the EIC, BoE, and 3% annuities, the results are restricted to these three securities. I find no evidence of momentum as α_2 is close to zero for all three securities. In contrast, and consistent with results in Tables VII and VIII, I do find evidence of reversals for the BoE and 3% annuities.

[Table XI about here]

D. Private Information

In addition to public news, private information might have been important as well. Research on current markets indicates that informed trading plays an important role (see for example Hasbrouck (1991), Easley, Kiefer, and O'Hara (1997). Anecdotal evidence suggests that the 18$^{\text{th}}$ century was no different. English insiders used the London and the Amsterdam markets to benefit from their private signals. In addition to public news, the packet boats transmitted private letters. London insiders would communicate private information to their agents in Amsterdam and these agents would trade on the information. The historical record is rife with examples of informed trading (Sutherland (1952), p. 206-208, 228; Van Nierop (1931), p. 68, Koudijs (2014)). It is likely that such trades set into motion a process of price discovery that affected prices both after the arrival of a boat and during subsequent periods without boats. For example, if insiders traded strategically, it would have taken considerable time before prices reflected a certain piece of information (Kyle (1985); see Glosten and Milgrom (1985) for an alternative setup). This could explain some of the return volatility in Amsterdam on the days no boats arrived from England.

I test this possibility in the following way. Suppose that, after the arrival of private signals, the insiders' agents in Amsterdam slowly traded on their information. This would have affected prices both after the arrival of a boat ($\Delta p_t^{AMS,boat}$) and during subsequent no-boat periods ($\Delta p_{t+d}^{AMS,no-boat}$). At the same time, the private information also affected the contemporaneous (but as-of-yet unreported) price change in London (Δp_s^{LND}). That is, the private signal was slowly incorporated into prices there as well (Figure 2). The co-movement between returns in Amsterdam after the arrival of a boat and price changes in London *after* *the departure* of that boat should therefore reflect the revelation of private information. It is important to note that this measure of private information excludes the revelation of short-lived private signals that immediately affected London prices – from the perspective of the Amsterdam investor, such signals are part of the public news transmitted by packet boats.

Table XII presents estimates of the regressions

$$\Delta p_t^{AMS,boat} = \alpha_0 + \alpha_1 \Delta p_s^{LND} + \alpha_2 \Delta p_{s-1}^{LND} + u_t$$
$$\Delta p_{t+d}^{AMS,no-boat} = \beta_0 + \beta_1 \Delta p_s^{LND} + v_t$$

for the three securities for which security prices in both Amsterdam and London are available. Columns (1) to (3) present the estimates for the Amsterdam boat returns ($\Delta p_t^{AMS,boat}$), while Columns (4) to (6) present the estimates for the no-boat returns ($\Delta p_{t+d}^{AMS,no-boat}$). For all three securities, there is a significant correlation between the returns.

[Table XII about here]

It is unlikely that these results are driven by the (slow) execution of English liquidity trades in the two markets. As before, it is natural to assume that liquidity trades have transitory price impact. If the London agent, who receives the liquidity shock, splits his trades across London and Amsterdam, we would expect to see reversals across markets. In particular, London returns Δp_s^{LND} that reflect this liquidity shock should negatively predict future price changes in Amsterdam that capture the reversal of this shock. The results in Tables VI to VIII do not support this conjecture.

These results support the idea that an important part of the return variance is driven by private information. The presence of informed trading also affects the estimates of the importance of public information. I quantify the impact of public and private information using a simple framework. The intuition can be formalized as follows. London price changes between the departures of two boats are given

$$\Delta p_s^{LND} = \eta_s + \varepsilon_s + u_s,$$

where η_s and ε_s are public and private signals revealed in London over period s. Innovation η_s is unknown to all parties at the beginning of period s and is revealed to the public during the course of the period. Innovation ε_s is privately observed by an insider at the beginning of s. For simplicity, I assume that ε_s is fully revealed to the public by the end of s.[28] Public and private signals η_s and ε_s are assumed to be independent and iid. Innovation u_s is a residual. Throughout, I assume that all innovations are normally distributed.

Returns in Amsterdam after the arrival of a boat can be expressed as

$$\Delta p_t^{AMS,boat} = \widetilde{\eta}_t + \lambda_0 \theta_t + v_t.$$

The variable θ_t is a noisy version of private information ε_s. The insider's agent in Amsterdam trades on the private information he has received from London and, by assumption, his trades are not fully informative. Instead, he generates a signal θ_t; without loss of generality $cov(\varepsilon_s, \theta_t) = \sigma_\varepsilon^2$ and $\sigma_{\theta_t}^2 > \sigma_\varepsilon^2$. The term $\lambda_0 \theta_t$ captures the response in Amsterdam to this noisy revelation of private information. The Amsterdam news return also responds to public information $\widetilde{\eta}_t$, which consists of public signal η_{s-1} and that part of private signal ε_{s-1} not yet incorporated into Amsterdam prices during the previous period. Innovation υ_t is a residual.

Amsterdam no-boat returns aren given by

$$\Delta p_{t+d}^{AMS,no-boat} = \lambda_d \theta_{t+d} + \upsilon_{t+d} \tag{2}$$

for $d \in [1, 7]$. The insider's agent keeps trading on the private signal. This trading generates an additional signal θ_{t+d}; again without loss of generalitym $cov(\varepsilon_s, \theta_{t+d}) = \sigma_\varepsilon^2$ and $\sigma_{\theta_{t+d}}^2 > \sigma_\varepsilon^2$. For simplicity I assume that the different signals $\theta_t, \theta_{t+1}, ...$are iid.[29] Finally, υ_{t+d} is a residual. It follows from the projection theorem that

$$\lambda_{\widehat{d}} = \frac{cov(\varepsilon_s, \theta_{t+d})}{var(\theta_{t+d})} = \frac{\sigma_\varepsilon^2}{\sigma_{\theta_{t+d}}^2} \tag{3}$$

for $\widehat{d} \in [0, 7]$. Using this expression, it is straightforward to show that

$$var\left(\Delta p_t^{AMS,boat}\right) = \underbrace{\sigma_{\widetilde{\eta}}^2}_{cov\left(\Delta p_t^{AMS,boat}, \Delta p_{s-1}^{LND}\right)} + \underbrace{\lambda_0 \sigma_\varepsilon^2}_{cov\left(\Delta p_t^{AMS,boat}, \Delta p_s^{LND}\right)} + \sigma_{\upsilon_t}^2 \tag{4}$$

$$var\left(\Delta p_{t+d}^{AMS,no-boat}\right) = \underbrace{\lambda_d \sigma_\varepsilon^2}_{cov\left(\Delta p_{t+d}^{AMS,no-boat}, \Delta p_s^{LND}\right)} + \sigma_{\upsilon_{t+d}}^2 \tag{5}$$

Equations (4) and (5) imply that the covariances between Amsterdam and London identify the importance of public and private information shocks for the overall return variance. Table XIV below presents the results. I find that public information explains between 47% and 56% of the variance of boat returns. Private information accounts for between 15% and 39% of the variance of boat returns and between 27% and 39% of the no-boat return variance.

E. Trading Costs

It is possible that the volatility of returns in Amsterdam in the absence of boats was driven by trading costs. Specifically, if market makers face order-handling costs or have limited risk bearing capacity, trades have an impact on prices (see O'Hara (1997) and Biais, Glosten, and Spatt (2005) for overviews). This could drive the return volatility in the absence of news.

E.1. Order-Handling Costs

I first consider order-handling costs. The Amsterdam market operated through limit orders and the *Amsterdamsche Courant* reported the going price of the day. In theory, the reported price should not reflect these direct transaction costs. Nevertheless, it is possible that there were de facto market makers who charged a bid-ask spread to cover order-handling costs. During certain days the market might have cleared at either the bid or the ask. This would have led to a bid-ask bounce that could have contributed significantly to the volatility of security returns. To analyze this, I estimate a Roll (1984b) model, where order-handling costs c are given by

$$c = -\sqrt{cov(\Delta p_t, \Delta p_{t-1})},$$

The return variance that can be attributed to these trading costs is given by $var(\Delta p_t) = 2c^2$.

Table XIII presents the results for both boat and no-boat periods. The underlying assumption is that transaction costs do not depend whether a boat arrives. For comparison, the table also presents the official brokers' fees; they are very close to the Roll measures. For the EIC, the first-order autocovariance is positive and the Roll measure cannot be calculated.

I therefore estimated the Roll model using a Bayesian approach advocated by Hasbrouck (2009) that can handle a positive autocovariance. This yields a Roll measure of $c = 0.047$ with an implied variance of 0.004. I apply Hasbrouck's approach to the other four securities as well. Without exception, the Bayesian approach leads to lower Roll measures (and lower implied variances) for these securities. For comparison, transaction costs on the NYSE between 1993 and 2005 were approximately twice as large as the (raw) Roll measures in the 1770s and 1780s (Hasbrouck (2009), Table 2).[30]

[Table XIII about here]

E.2. Inventory Costs

The Roll model abstracts from other sources of transaction costs such as inventory costs, where intermediaries have to be compensated for taking a position in the asset (because of risk aversion or inventory management). This could be especially relevant in the limit order setting of the 18$^{\text{th}}$ century. If, for example, there are many transactions on one side of the market, trades will take place deeper in the limit order book, which affects all transaction prices during the trading day. Consider the following stylized setup. There is a competitive group of intermediaries that sets prices according to

$$p_t = f_t - \lambda I_t, \tag{6}$$

where f_t is the log fundamental value of the security with $f_t = f_{t-1} + u_t$ and I_t is the intermediaries' total inventory in the asset. The parameter λ captures market makers' risk-bearing capacity. Returns are given by

$$\Delta p_t = u_t + \lambda q_t, \tag{7}$$

where q_t is either a buy or sell order. In practical terms, this setting differs from the Roll (1984b) model if it takes time for intermediaries to off-load their inventory. In that case, the initial price impact of q_t will dissipate slowly and the autocovariance of returns will be negative at longer lag lengths. The results in Tables VI to VIII provide evidence of negative autocorrelations for up to one week.

To analyze the impact on returns, I simulate a simple inventory cost model. Following Garman (1976) and Ho and Stoll (1981), I assume that orders arrive following

$$q_t = \left\{ \begin{array}{c} 1 \text{ with probability } \pi_t \\ -1 \text{ with probability } 1 - \pi_t \end{array} \right\},$$

where

$$\pi_t = \min \left\{ \max \left[\frac{1}{2} + \rho(f_{t-1} - p_{t-1}), 1 \right], 0 \right\}. \tag{8}$$

In other words, the probability of a buy or sell order depends on the log-difference between the asset's fundamental value and the market price during the previous period. If the asset is undervalued, it is more likely that a buy order will hit the market and, as a result, prices will rise. This process generates negative autocorrelation in the order flow and the return series: a buy order today will drive up prices, making a sell order tomorrow more likely. The parameter ρ captures how fast the market responds to mispricing. A low value implies a longer time before prices move back to fundamentals, leading to negative autocovariances at longer lag lengths. Section V.H of the Internet Appendix illustrates this with two examples, where $\lambda = 1/2$ and $\rho \in \{1/4, 3/4\}$.

I simulate price paths of 10,000 observations for different values of λ and ρ, and compare the implied autocovariances $cov(\Delta p_t, \Delta p_{t-l})$ over different lag lengths with the actual ones in the data, again using both boat and no-boat returns (the first 1,000 observations for each simulated price series are dropped). Lag lengths can vary between one and 12 periods, $l \in [1, 12]$, where each lag represents two or three days. The longest lag is equivalent to a period of four weeks. Table XIII presents, for each individual security, the values of λ and ρ for which the mean squared error is minimized. Section V.H of the Internet Appendix presents the actual and model-simulated autocovariances for these parameter estimates. For the EIC, there is no evidence of a negative autocovariance at the first two lags, and $\lambda = 0$ provides the best description of the data. For the SSC, the autocovariance of returns is only negative at a lag length of one, consistent with a relatively large value for ρ. For the BoE and the two annuities autocovariances are negative at the first three lag lengths, and ρ has a relatively small value.

Table XIII above presents estimates of the return variance that this process generates. These estimates, which are based on the simulated return series, are somewhat higher than those of the Roll model. As a cross-validation I check these numbers against the (limited) transaction data available. Of the 32 individual transactions that I could be identify, nine took place in the absence of boat arrivals, on days for which prices were listed (Mondays, Wednesdays, and Fridays), and for future contracts with the same maturity as those reported in the newspaper. For these nine transactions, the mean squared difference between the transaction and the reported price is 0.079. This estimate is in the same ballpark as the inventory cost model's implied variance.

F. Summing Up

Table XIV summarizes the contributions of the different factors that drive security returns. On days *with* a boat arrival, between 47% and 56% of the return variance can be attributed to the arrival of public information. Private information is also of key importance, explaining about 39% of returns for the EIC, while it explains between 13% and 20% of returns for the BoE and 3% annuities respectively. Trading costs are estimated to be zero for the EIC, while they account for between 22% and 25% of the return variance for the BoE and 3% annuities. For days *without* a boat, private information accounts for between 26% and 39% of the return variance. Trading costs are again estimated to be zero for the EIC and account for between 38% and 54% of the return variance for the other two securities. *Overall*, public news accounts for between 36% and 42%, private information for between 17 and 39%, and trading costs for between 0% and 32% of the total return variance. Taken together, these estimates explain between 82% and 92% of overall price movements.

[Table XIV about here]

There is one case with a relatively poor fit. For EIC returns on days without a boat, more than 60% of the return variance is left unexplained. To investigate this finding further, Table XV presents more detailed information about the EIC's one-period autocovariance.

In particular, the table reports results of the following regressions:

$$\Delta p_t^{AMS} = \alpha_0 + \alpha_1 \Delta p_{t-1}^{AMS} + \alpha_2 \Delta p_{t-1}^{AMS} * B_{t-1} + \alpha_3 B_{t-1} + u_t \tag{9}$$

$$\Delta p_t^{AMS} = \beta_0 + \beta_1 \Delta p_{t-1}^{AMS} + \beta_2 \Delta p_{t-1}^{AMS} * B_{t-1} + \beta_3 \Delta p_{t-1}^{AMS} * B_t \tag{10}$$

$$+ \beta_4 \Delta p_{t-1}^{AMS} * B_{t-1} * B_t + \beta_5 B_{t-1} + \beta_6 B_t + \beta_7 B_{t-1} * B_t + v_t,$$

where $B_t \in \{0, 1\}$ indicates whether new information reached Amsterdam in period t. These regressions test whether return reversals differed if the previous and/or current period featured the arrival of a boat. To facilitate interpretation, Table XV sums up the different interaction coefficients to calculate the total return reversal for each different scenario. Column (1) presents the estimates of equation (9), where boat and no-boat returns are allowed to revert differently ($B_{t-1} = 0, 1$). Columns (2) and (3) present the estimates of equation (10), where reversals coefficients are also allowed to be different depending on whether the current period features the arrival of a boat or not ($B_t = 0, 1$).

Table VI provides no evidence of negative autocovariance for the EIC. In Table XV, I find that there are reversals, but only of no-boat returns ($B_{t-1} = 0$), and only on on news days ($B_t = 1$). For comparison, the table also presents estimates for the BoE and 3% annuities. For the latter, return reversals are also important for no-boat returns, although returns tend to revert equally strong regardless of whether a boat just arrived. For the BoE, no differences in reversals are visible.

[Table XV about here]

The unexplained volatility of EIC stock on no-boat days may be due to liquidity trades and adverse selection costs. The analysis of Section E. suggests that trading costs in EIC stock were practically zero. These calculations yield incorrect results if liquidity trades were mainly concentrated in periods without a boat arrival. It is possible that due to the presence of privately informed agents, uninformed traders concentrated their trades in periods without a boat arrival (Admati and Pfleiderer (1988)). According to Table XIV, 39% of the EIC return variance on news days was driven by private information. This is significantly more than for the other securities. In addition, Table XII suggests that privately informed trading in EIC stock was approximately twice as important on boat days than on no-boat days. This would have led to additional adverse selection costs on days boats arrived, in which case uniformed agents may have decided to cluster their trades in no-boat periods. The price impact of these liquidity trades would have reversed only after the arrival of the next boat, when uncertainty was resolved, decreasing the risk premium charged by intermediaries. This interpretation is consistent with the limited trading data available: each of the 11 transactions in EIC stock took place on no-boat days, which is statistically different (with a p-value of 0.025) from a random allocation of trades over days with or without a boat arrival (based on a one-sided binomial test).

Alternatively, the unexplained volatility of EIC stock on no-boat days could be the result of sentiment shocks, rumors, or differences of opinion. Under this interpretation, beliefs would have converged after the arrival of news from England, leading to return reversals. Since the EIC was by far the most volatile stock of the period, it is possible that sentiment shocks were most important for this security (Baker and Wurgler (2006); Tetlock (2007)). It is impossible to differentiate between these two interpretations. The transaction evidence is not conclusive, since differences in beliefs are generally also associated with higher trading volume (Harris and Raviv (1993)).

V. Conclusion

What are the roles of public news, private information, liquidity trades, and sentiment shocks in explaining the short-term volatility of stock returns? It is difficult to answer this question in today's world of around-the-clock news coverage and instant, long-distance data exchange. In particular, with news arriving all the time, it is difficult to separate the impact of news arrival from the trading process.

The key contribution of this paper lies in the identification of news flows. I examine the trade of English securities in 18^{th} century Amsterdam. Communication between England and the Dutch Republic relied on sailboats. This makes it possible to precisely reconstruct the arrival of news and study stock price movements in the absence of news. Moreover, interruptions in information flows were exogenous as delays in boat arrival were the result of adverse winds and other weather conditions, and the arrival of news was unrelated to developments in the stock market or general economic and political events.

At the same time, Amsterdam and London, the markets in question, were already quite developed in the 18^{th} century. For instance, they share many important features of modern stock markets: a centralized exchange, trade in derivatives (with the ability to short), and a well-developed system of margin loans to finance positions. Harrison (1998) further argues that the return process has changed little over time, leading him to conclude that 18^{th} century markets were not so different from the 1990s. The current paper's estimates of trading costs and return reversals are also surprisingly similar to modern figures (compare Hasbrouck (2009) and Tetlock (2010)). The fact that communication technology itself was less developed at the time is not particularly relevant. What matters is how markets respond to information, not how that information arrives to the market.[31]

The results indicate that the arrival of public information was important: the variance of returns in Amsterdam was significantly higher after the arrival of boats. Public news explains about 40% of the overall volatility in Amsterdam. At the same time, price movements in the absence of boats were considerable. The results suggest that the no boat return variance can be almost fully explained by private information and liquidity shocks (in approximately the same proportions). The exception is the EIC – returns in the absence of boat arrivals remain largely unexplained for this security. It is possible that, due to adverse selection costs, uninformed agents concentrated their liquidity trades in periods between boat arrivals, leading to additional volatility. Alternatively, investor sentiment may have shifted during periods when no new objective information was available.

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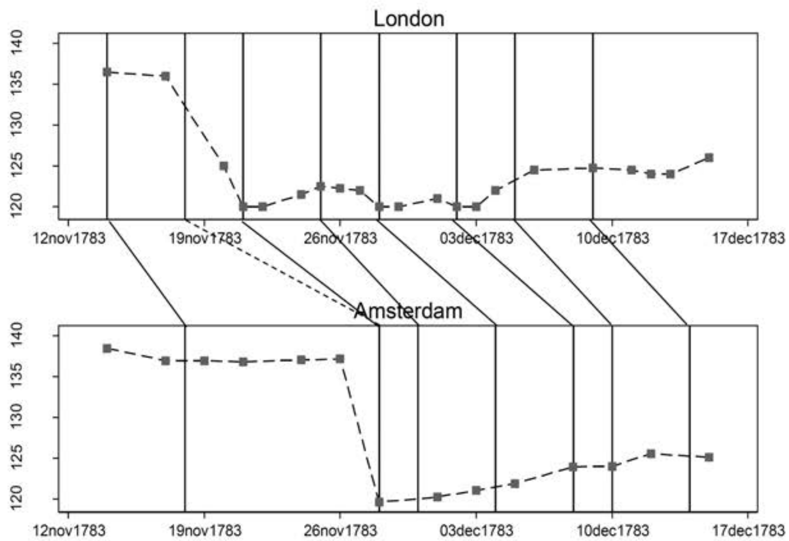
Figures and Tables

Panel A: Announcement of Prime Minister Fox, November 18, 1783



Panel B: Unfavorable sailing conditions on North Sea, Winter 1776

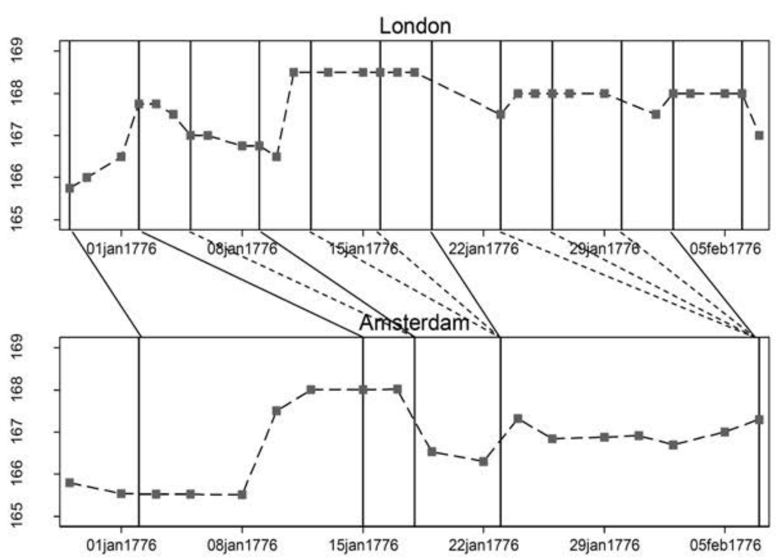


Figure 1: Examples. The figure presents examples of news transmission and price movements for EIC stock. Vertical/ diagonal lines indicate the flow of news between London and Amsterdam, solid lines indicate the most recent news transmission, dashed lines indicate stale news, and squares indicate actual prices – dashed lines intrapolate between price observations. Prices recorded on days with a boat arrival reflect the information transmitted by that boat. Prices in both London and Amsterdam are spot prices.

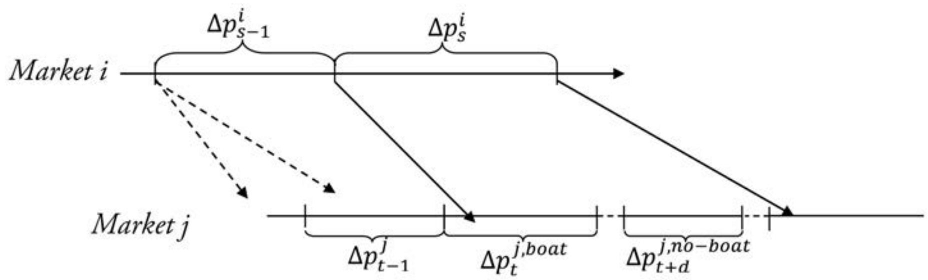


Figure 2: Structure of return data. This figure illustrates the structure of the return data. $i, j \in \{LND, AMS\}$, with $i \neq j$, t indexes returns over two or three days (Monday-to-Wednesday, Wednesday-to-Friday, or Friday-to-Monday), s indexes periods in the other market between two subsequent boat departures. $\Delta p_t^{j,boat}$ reflects the arrival of a boat that transmits between-boat return Δp_{s-1}^i. If the period between the arrival of two boats is long enough, there will be returns that take place in the absence of a boat arrival, $\Delta p_{t+d}^{j,no-boat}$. There are at most seven no-boat returns per period; $d \in [1, 7]$ (see Table I). Δp_{s-1}^i is the contemporaneous return in the other market. Δp_{t-1}^j is the preceding return in the own market, which may or may not reflect the arrival of a boat.

Table I
Descriptive Statistics

Panel A presents descriptive statistics for Amsterdam security returns for the two sample periods (1771 to 1777 and 1783 to 1787) as well as the entire 1771 to 1787 period. Two- or three-day log percentage returns are calculated as $log(p_t/p_{t-1})$. panel B provides descriptive statistics for Amsterdam security returns for non-overlapping two-week periods, based on the data collected by Van Dillen (1931). The table includes a Brown-Forsythe test statistic on the equality of different return variances. Panel C summarizes between-boat periods for the two sample periods. Periods involving a no-boat return are long enough that there is at least one price change in the absence of news. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Return information 1771 to 1787 (two- or three-day returns)					
	EIC	SSC	BoE	3% ann.	4% ann.
September 1771 to December 1777 and September 1783 to March 1787 (the two sample periods)					
Mean	0.056	0.031	0.032	0.042	0.033
Variance	0.528	0.264	0.188	0.330	0.237
N (total)	1162	1162	1162	1162	1162
N (news returns)	681	681	681	681	681
N (no-news returns)	481	481	481	481	481
September 1771 to March 1787 (the two sample periods and the intermediate war period)					
Mean	0.051	0.034	0.040	0.035	0.044
Variance	0.618	0.443	0.292	0.523	0.396
N (total)	1900	1900	1900	1900	1767
B-F statistic on equality return variance	(12.4)***	(51.9)***	(52.8)***	(63.8)***	(79.4)***

Panel B: Return information 1723 to 1794 (non-overlapping two-week returns)					
September 1771 to December 1777 and September 1783 to March 1787 (the two sample periods)					
Mean	0.079	-0.003	0.019	N/A	
Variance	5.173	1.920	2.448		
N	133	133	133		
November 1723 to December 1794 (the full period for which data are available, with gaps)					
Mean	0.037	0.047	0.007	N/A	
Variance	3.876	2.236	2.534		
N	957	957	957		
B-F statistic on equality return variance	(4.24)**	(0.039)	(0.046)		

Panel C: Between-boat periods (September 1771 to December 1777 and September 1783 to March 1787)					
Number of between-boat periods	681				
Those involving a no-boat return	383				
	min	5th perc.	median	95th perc.	max
Length between boat periods (days)	1	2	3	7	21
Number of price observations per period	0	1	2	3	8

Table II
Response to News, Amsterdam and London

This table presents estimates of the response of news returns in Amsterdam (AMS) and London (LND) to returns observed in the other market: $\Delta p_t^{AMS,boat} = \alpha_0 + \alpha_1 \Delta p_{s-1}^{LND} + \alpha_2 \Delta p_{s-2}^{AMS} + u_t$ and $\Delta p_t^{LND,boat} = \beta_0 + \beta_1 \Delta p_{s-1}^{AMS} + \beta_2 \Delta p_{s-2}^{LND} + v_t$. $\Delta p_t^{AMS,boat}$ and $\Delta p_t^{LND,boat}$ reflect the arrival of a boat from the other market and are calculated as percentage log returns over two- or three-day periods. Returns observed in the other market, Δp_{s-1}^{LND} and Δp_{s-1}^{AMS}, are defined as price changes between boat departures. Δp_{s-2}^{LND} and Δp_{s-2}^{AMS} are past London and Amsterdam returns. Robust bootstrapped (1000 replications) standard errors are reported in parentheses. Sample periods: September 1771 to December 1777 and September 17 to March 1787. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	AMS (response to LND) $\Delta p_t^{AMS,boat}$			LND (response to AMS) $\Delta p_t^{LND,boat}$		
	EIC	BoE	3% ann.	EIC	BoE	3% ann.
Observed LND return	0.380	0.425	0.483			
(Δp_{s-1}^{LND})	(0.041)***	(0.058)***	(0.074)***			
Past AMS return	−0.021	−0.004	−0.040			
(Δp_{s-2}^{AMS})	(0.038)	(0.003)	(0.038)			
Observed AMS return				0.056	0.053	0.064
(Δp_{s-1}^{AMS})				(0.033)*	(0.038)	(0.033)*
Past LND return				−0.026	−0.068	−0.056
(Δp_{s-2}^{LND})				(0.035)	(0.052)	(0.036)
Constant	0.054	0.018	0.037	0.006	0.019	0.016
	(0.030)*	(0.015)	(0.021)*	(0.032)	(0.019)	(0.017)
N	594	602	621	636	629	756
Adj. R^2	0.21	0.26	0.24	0.00	0.00	0.01

Table III
Hasbrouck Information Shares

This table reports Hasbrouck information shares based on VECM models that use prices in Amsterdam and London three days a week (Monday, Wednesday, and Friday). The VECM models are estimated using five lags; each lag represents two or three days. The reported information shares are for different Cholesky orderings (either London or Amsterdam first) and the simple mean of the two. Panel A presents results for the two sample periods that are characterized by peace. Panel B presents results for the intermediate period of international conflict.

Panel A: September 1771 to December 1777 and September 1783 to March 1787			
		Ordering	
	LND first	AMS first	Midpoint
EIC	0.998	0.867	0.933
BoE	0.992	0.854	0.923
3% Ann.	0.999	0.973	0.986
Obs.	1498		
Panel B: January 1778 to August 1783			
EIC	0.799	0.552	0.676
BoE	0.730	0.424	0.577
3% Ann.	0.864	0.647	0.756
Obs.	834		

Table IV
Correlation Between English and Dutch Security Returns in Amsterdam

This tables presents regressions of English security returns on Dutch security returns in Amsterdam. Returns are for periods without news from London only. VOC: Dutch East India Company; WIC: Dutch West Indies Company; and Bank money (agio): return on deposit money at the Bank of Amsterdam relative to cash. Percentage log returns are calculated over two- or three-day periods. Sample periods: September 1771 to December 1777 and September 1783 to March 1787. ** denotes statistical significance at the 5% level.

				$\Delta p_{t+d}^{AMS,no-boat}$		
		EIC	SSC	BoE	3% Ann.	4% Ann
$\Delta p_t^{AMS,no-news}$	VOC	0.078	0.061	0.078	0.033	0.061
		(0.057)	(0.043)	(0.039)**	(0.045)	(0.041)
	WIC	0.031	0.001	−0.005	−0.006	−0.005
		(0.024)	(0.021)	(0.018)	(0.023)	(0.024)
	Bank money (agio)	0.290	0.171	−0.021	−0.137	−0.071
		(0.326)	(0.284)	(0.222)	(0.269)	(0.321)
Constant		0.013	0.015	0.003	0.002	0.014
		(0.024)	(0.020)	(0.017)	(0.021)	(0.018)
N		426	426	426	426	426
R^2		0.01	0.01	0.02	0.00	0.01

Table V

The impact of Different News Categories on EIC Returns

This table presents regression results relating squared Amsterdam EIC news returns to the publication of relevant capitalized words in articles with news from England published in the *Leydse Courant* between September 1771 and December 1777. *EIC*: East India Company; *Finance*: financial terminology (excludes "stocks"); *India*: reference to regions, towns, and/or persons in the British East Indies; *Cape*: references to the Cape (of Good Hope Colony); *Background*: words signalling background information (Section V.B of the Internet Appendix provides further details). News related to the EIC is captured by two dummy variables: *EIC* (1) takes a value of one if the EIC is mentioned once in an article. *EIC* (>1) takes a value of one if the EIC is mentioned at least twice. The other news variables are also included as dummies, where a dummy takes a value of one if a specific category is referenced at least once. The "Obs." column indicates for how many observations a certain (combination of) dummy(ies) is turned on. Robust bootstrapped (1000 replications) standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	$(\Delta p_t^{AMS,boat})^2$						
	(1)	(2)	(3)	(4)	(5)	(6)	Obs.
EIC (1)	-0.023	0.029	-0.022	0.077	0.015	0.095	101
	(0.183)	(0.186)	(0.202)	(0.184)	(0.225)	(0.241)	
EIC (>1)	1.487	1.063	1.462	1.040	1.701	1.434	28
	(0.843)*	(0.802)	(0.961)	(0.838)	(0.927)*	(1.151)	
Finance	1.133	0.152	1.128	0.115	1.088	0.122	15
	(0.659)*	(0.501)	(0.724)	(0.398)	(0.669)	(0.482)	
India	-0.243	-0.349	-0.292	-0.485	-0.277	-0.334	32
	(0.260)	(0.238)	(0.145)**	(0.215)**	(0.274)	(0.142)**	
Cape	0.916	0.162	0.907	-0.449	0.878	-0.457	11
	(0.915)	(0.591)	(0.944)	(0.131)***	(0.886)	(0.119)***	
Background	-0.388	-0.348	-0.386	-0.346	-0.297	-0.257	98
	(0.130)***	(0.120)***	(0.126)***	(0.123)***	(0.145)**	(0.142)*	
EIC (1)* *Finance*		0.151				0.156	5
		(0.922)				(0.910)	
EIC (>1)* *Finance*		5.355				-1.176	3
		(3.537)				(1.234)	
EIC (1)**India*			0.038			-0.029	18
			(0.270)			(0.276)	
EIC (>1)**India*			0.190			-1.141	5
			(1.717)			(1.439)	
EIC (1)**Cape*				-0.322		-0.311	3
				(0.212)		(0.251)	
EIC (>1)**Cape*				9.181		10.480	2
				(1.720)***		(1.494)***	
EIC (1)* *Background*					-0.166	-0.250	16
					(0.266)	(0.252)	
EIC (>1)* *Background*					-1.806	-1.612	3
					(0.941)*	(1.164)	
Constant	0.665	0.689	0.667	0.702	0.649	0.681	
	(0.102)***	(0.099)***	(0.103)***	(0.100)***	(0.107)***	(0.102)***	
Obs.	512	512	512	512	512	512	
Adj. R^2	0.051	0.077	0.047	0.111	0.051	0.106	
Adj. R^2 using $\|\Delta p_t^{AMS,boat}\|$	0.045	0.063	0.041	0.083	0.046	0.077	

Table VI
Predictive Regressions - EIC

This table presents results on whether, and over what horizons, returns revert. Panel A examines reversals within the Amsterdam market: $\Delta p_{t+T}^{AMS} = \alpha_0 + \alpha_1 \Delta p_t^{AMS} + u_t$, where Δp_{t+T}^{AMS} is the Amsterdam return from t to T, and T lies between two or three days and four weeks. Δp_t^{AMS} is the usual Amsterdam two- or three-day return. Panel B focuses on reversals across markets: $\Delta p_{t+T}^{AMS} = \beta_0 + \beta_1 \Delta p_{s-1}^{LND} + v_t$ for $B_t = 1$, where Δp_{t+T}^{AMS} is defined as before, $B_t = 1$ indicates that a boat arrived in t, and Δp_{s-1}^{LND} is the London return observed during that period. See Figure 2 for more details. Note that Δp_{t+T}^{AMS} does not capture the Amsterdam response to the news from London. Panel C examines return reversals within the London market: $\Delta p_{t+T}^{LND} = \gamma_0 + \gamma_1 \Delta p_t^{LND} + w_t$ where Δp_t^{LND} is the two- or three-day return in London and Δp_{t+T}^{LND} is the return in London between t and T. Robust bootstrapped (1000 replications) standard errors are presented in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Panel A: Future Amsterdam EIC Returns (Δp_{t+T}^{AMS})					
	2/3 days	4/5 days	1 week	2 weeks	3 weeks	4 weeks
Current Amsterdam EIC	0.009	0.006	0.005	0.035	0.039	0.088
returns (Δp_t^{AMS})	(0.034)	(0.052)	(0.056)	(0.072)	(0.092)	(0.0103)
Constant	0.032	0.063	0.092	0.172	0.253	0.339
	(0.018)*	(0.026)*	(0.032)***	(0.046)***	(0.058)***	(0.068)***
N	1540	1535	1530	1515	1500	1485
Adj. R^2	0.00	0.00	0.00	0.00	0.00	0.00

	Panel B: Future Amsterdam EIC Returns (Δp_{t+T}^{AMS})					
London news EIC	0.042	0.032	0.084	0.055	0.072	0.176
returns (Δp_{s-1}^{LND})	(0.043)	(0.060)	(0.060)	(0.077)	(0.103)	(0.115)
Constant	-0.015	0.003	0.057	0.124	0.153	0.209
	(0.028)	(0.039)	(0.048)	(0.067)*	(0.087)*	(0.102)**
N	737	736	735	731	724	722
Adj. R^2	0.00	0.00	0.00	0.00	0.00	0.00

	Panel C: Future London EIC Returns (Δp_{t+T}^{LND})					
Current London EIC	0.020	-0.011	0.025	0.042	0.063	0.146
returns (Δp_t^{LND})	(0.046)	(0.062)	(0.081)	(0.082)	(0.099)	(0.104)
Constant	0.027	0.042	0.053	0.106	0.157	0.199
	(0.023)	(0.032)	(0.039)	(0.055)*	(0.067)**	(0.077)***
N	1167	1302	1322	1335	1336	1336
Adj. R^2	0.00	0.00	0.00	0.00	0.00	0.00

Table VII
Predictive Regressions - BoE

See Table VI for details.

	Panel (1): Future Amsterdam BoE Returns (Δp_{t+T}^{AMS})					
	2/3 days	4/5 days	1 week	2 weeks	3 weeks	4 weeks
Current Amsterdam BoE	-0.049	-0.086	-0.049	0.009	0.032	0.154
returns (Δp_t^{AMS})	(0.036)	(0.044)**	(0.054)	(0.077)	(0.096)	(0.118)
Constant	0.027	0.056	0.079	0.155	0.233	0.315
	(0.012)**	(0.016)***	(0.020)***	(0.028)***	(0.036)***	(0.043)***
N	1540	1535	1530	1515	1500	1485
Adj. R^2	0.00	0.00	0.00	0.00	0.00	0.00
	Panel (2): Future Amsterdam BoE Returns (Δp_{t+T}^{AMS})					
London news BoE	0.018	0.099	0.091	0.206	0.211	0.355
returns (Δp_{s-1}^{LND})	(0.057)	(0.078)	(0.081)	(0.103)**	(0.130)	(0.157)**
Constant	0.029	0.059	0.072	0.145	0.254	0.316
	(0.017)*	(0.023)***	(0.028)***	(0.039)***	(0.051)***	(0.059)***
N	707	707	705	699	692	689
Adj. R^2	0.00	0.01	0.01	0.01	0.01	0.02
	Panel (3): Future London BoE Returns (Δp_{t+T}^{LND})					
Current London BoE	-0.049	-0.106	-0.038	0.049	0.086	0.207
returns (Δp_t^{LND})	(0.045)	(0.054)**	(0.069)	(0.087)	(0.106)	(0.118)
Constant	0.029	0.054	0.081	0.165	0.235	0.311
	(0.014)**	(0.018)***	(0.021)***	(0.030)***	(0.038)***	(0.045)***
N	1156	1319	1339	1344	1344	1344
Adj. R^2	0.00	0.01	0.00	0.00	0.00	0.00

Table VIII
Predictive Regressions - 3 % annuities

See Table VI for details.

	Panel (1): Future Amsterdam 3% Ann. returns (Δp_{t+T}^{AMS})					
	2/3 days	4/5 days	1 week	2 weeks	3 weeks	4 weeks
Current Amsterdam 3%	-0.125	-0.189	-0.197	-0.164	-0.152	0.020
Ann. returns (Δp_t^{AMS})	(0.035)***	(0.049)***	(0.062)***	(0.080)*	(0.100)	(0.121)
Constant	0.033	0.064	0.093	0.169	0.251	0.332
	(0.015)**	(0.020)***	(0.023)***	(0.032)***	(0.039)***	(0.046)***
N	1540	1535	1530	1515	1500	1485
Adj. R^2	0.02	0.02	0.02	0.01	0.00	0.00

	Panel (2): Future Amsterdam 3% Ann. returns (Δp_{t+T}^{AMS})					
returns (Δp_{s-1}^{LND})	(0.048)	(0.056)*	(0.078)	(0.093)**	(0.117)*	(0.135)***
Constant	0.006	0.040	0.067	0.139	0.245	0.311
	(0.019)	(0.025)	(0.029)**	(0.040)***	(0.050)***	(0.058)***
N	865	864	860	852	842	838
Adj. R^2	0.00	0.01	0.01	0.01	0.01	0.03

	Panel (3): Future London 3% Ann. returns (Δp_{t+T}^{LND})					
Current London 3% Ann.	-0.031	-0.083	-0.059	0.035	0.064	0.191
returns (Δp_t^{LND})	(0.039)	(0.052)	(0.068)	(0.099)	(0.113)	(0.125)
Constant	0.026	0.056	0.075	0.151	0.233	0.315
	(0.013)**	(0.018)***	(0.022)***	(0.031)***	(0.039)***	(0.046)***
N	1516	1537	1539	1539	1539	1539
Adj. R^2	0.00	0.00	0.00	0.00	0.00	0.00

Table IX
Benchmark Results

This tables presents descriptive statistics for Amsterdam percentage log returns over two- or three-day periods (denoted t) with or without a boat arrival ($B_t = 1$ or $B_t = 0$). Sample periods: September 1771 to December 1777 and September 1783 to March 1787. The equality of the variance of boat and no-boat returns is tested using a Brown-Forsythe (B-F) test ($H_0 : ratio = 1$). *** Indicates statistical significance at the 1% level.

				Δp_t^{AMS}		
		EIC	SSC	BoE	3% ann.	4% ann.
Mean	Boat ($B_t = 1$)	0.084	0.037	0.043	0.062	0.041
	No-boat ($B_t = 0$)	0.018	0.023	0.017	0.012	0.022
	(t-statistic)	(1.526)	(0.456)	(1.032)	(1.350)	(0.635)
Variance	Boat ($B_t = 1$)	0.703	0.325	0.229	0.425	0.299
	No-boat ($B_t = 0$)	0.279	0.179	0.131	0.194	0.150
	(B-F statistic)	(42.3)***	(20.8)***	(24.8)***	(22.9)***	(30.4)***
Skewness	Boat ($B_t = 1$)	0.189	−0.030	0.169	0.441	−0.505
	No-boat ($B_t = 0$)	0.030	0.649	0.523	0.135	1.371
Kurtosis	Boat ($B_t = 1$)	7.52	8.52	7.99	11.38	10.40
	No-boat ($B_t = 0$)	8.68	7.88	10.95	8.22	10.87
% zero	Boat ($B_t = 1$)	13.5	38.0	22.8	29.5	50.6
	No-boat ($B_t = 0$)	27.0	54.7	38.3	41.0	65.3
Obs.	Boat ($B_t = 1$)	681	681	681	681	680
	No-boat ($B_t = 0$)	481	481	481	481	481
$\frac{var\left(\Delta p_{t+d}^{AMS,no-boat}\right)}{var\left(\Delta p_t^{AMS,boat}\right)}$		0.397	0.550	0.575	0.457	0.499

Table X

Summary of Potential Explanations for Price Movements in Amsterdam

This table summarizes the potential factors influencing stock prices in Amsterdam during periods with and without boat arrivals, making a distinction between factors originating in London or Amsterdam. "Y/N": explanation relevant (yes/no) according to empirical evidence. The table reports that there is no evidence that liquidity or sentiment shocks from London affected prices in Amsterdam. This statement is based on the assumption that potential liquidity and sentiments shocks should, noticeably, revert at some time in the future.

Explanation:		Mechanism:	Boat returns	No-boat returns
Public news	from London	Announcements	Y	N
	from Amsterdam	" "	N	N
Private information	from London	Trading activity	Y	Y
	from Amsterdam	" "	N	N
Liquidity shocks	from London	" "	N	N
	from Amsterdam	" "	Y (except EIC)	Y (except EIC?)
Sentiment shocks	from London	" "	N	N
	from Amsterdam	" "	N	N (except EIC?)

Table XI

Momentum

This table presents estimates for

$$\Delta p_t^{AMS} = \alpha_0 + \alpha_1 \Delta p_{t-1}^{AMS,boat} + \alpha_2 \Delta p_{s-2}^{LND} + \varepsilon_t \text{ for } B_{t-1} = 1,$$

where $B_{t-1} = 1$ indicates that a boat arrived in period $t-1$, Δp_t^{AMS} is the current Amsterdam return, which can take place in the presence or absence of a boat, $\Delta p_{t-1}^{AMS,boat}$ is the previous period's Amsterdam boat return, and Δp_{s-2}^{LND} is the London news return observed in the previous period. α_1 measures the reversal of Amsterdam returns, and α_2 measures the continuation of London news returns. Robust bootstrapped (1000 replications) standard errors are reported in parentheses. * indicates statistical significance at the 10% level.

	Current Amsterdam return: Δp_t^{AMS}		
	EIC	BoE	3% ann.
Amsterdam news return, previous period	0.059	-0.055	-0.081
$(N_{t-1} = 1)$: $\Delta p_{t-1}^{AMS,news}$	(0.053)	(0.064)	(0.057)
London news return, observed in previous	-0.003	-0.038	-0.007
period $(N_{t-1} = 1)$: Δp_{s-2}^{LND}	(0.042)	(0.064)	(0.065)
Constant	0.009	0.032	0.031
	(0.029)	(0.017)*	(0.020)
N	623	634	655
Adj. R^2	0.00	0.01	0.01

Table XII
Private Information: News and No-News Returns

This table presents estimates of the impact of private information on security returns in Amsterdam on days with and without a boat arrival: $\Delta p_t^{AMS,boat} = \alpha_0 + \alpha_1 \Delta p_s^{LND} + \alpha_2 \Delta p_{s-1}^{LND} + u_t$ for $B_t = 1$ and $\Delta p_{t+d}^{AMS,noboat} = \beta_0 + \beta_1 \Delta p_s^{LND} + v_t$ for $B_t = 0$. Returns are defined in Figure 2. London returns Δp_s^{LND} are defined as the price change after the departure of a boat (up to the departure of the next boat) and capture contemporaneous (but as-of-yet) unreported returns. For comparison, the table reports the impact of Δp_{s-1}^{LND}, the return in London before the departure of a boat, capturing the impact of the arrival of public news. Robust bootstrapped (1000 replications) standard errors are reported in parentheses. *** and ** denote statistical significance at the 1% and 5% level, respectively.

	Amsterdam boat returns ($\Delta p_t^{AMS,boat}$)			Amsterdam no-boat returns ($\Delta p_{t+d}^{AMS,no-boat}$)		
	EIC	BoE	3% ann.	EIC	BoE	3% ann.
London post-departure	0.233	0.138	0.147	0.138	0.168	0.132
returns (Δp_s^{LND})	(0.042)***	(0.050)***	(0.067)**	(0.034)***	(0.043)***	(0.052)***
London pre-departure	0.373	0.405	0.503			
returns (Δp_{s-1}^{LND})	(0.042)***	(0.054)***	(0.070)***			
Constant	0.045	0.025	0.033	0.006	0.003	0.006
	(0.028)	(0.017)	(0.022)	-0.024	-0.016	0.020
N	622	640	669	467	465	479
Adj. R^2	0.286	0.250	0.261	0.053	0.066	0.033

Table XIII
Trading Costs

This tables presents estimates of trading costs. Panel A refers to order handling consts. The "fees" indicate official broker's fees. Fees were 0.125% of a security's nominal or par value. To arrive at the fees presented here, the "nominal" fee is multiplied by the average security price. Estimates of Roll's (1984b) "raw" trading cost measure are given by $c = -\sqrt{cov(\Delta p_t, \Delta p_{t-1})}$. For the EIC, the raw Roll measure cannot be calculated since the first-order autocovariance is positive. The panel therefore also presents estimates using Hasbrouck's (2009) Bayesian estimation. The implied variance is given by $var(\Delta p_t) = 2c^2$. Panel (B) refers to inventory costs and estimates are based on the simple model presented in the main text: $\Delta p_t = \Delta f_t + \lambda q_t$, where $q_t = \{1, -1\}$ with probability $\{\pi_t, 1 - \pi_t\}$, where $\pi_t = \min\{\max[1/2 + \rho(f_{t-1} - p_{t-1}), 1], 0\}$. Estimates of λ and ρ are based on minimizing the mean squared error of the empirical and model-implied autocovariances (up to 12 lags; four weeks). Section V.F in the Internet Appendix provides a graphical presentation of the fit of the data and the parameters that minimize the mean squared error. The implied variance is calculated from the simulated return series.

	EIC	SSC	BoE	3% ann.	4% ann.
		Panel A: Order Handling Costs			
Fees (%)	0.078	0.142	0.090	0.159	0.142
Roll measure (raw) (%)	-	0.196	0.122	0.225	0.192
Implied variance	0	0.066	0.048	0.100	0.082
Roll measure (Hasbrouck) (%)	0.047	0.101	0.054	0.111	0.099
Implied variance	0.004	0.020	0.006	0.025	0.020
		Panel B: Inventory Costs			
λ	0	0.263	0.222	0.323	0.283
ρ	0	3.111	1.899	2.869	1.455
Implied variance	0	0.069	0.049	0.105	0.080

Table XIV

Summary Results

This table presents results of a simple variance decomposition. The impact of public and private information is identified through the covariances with London pre- and post-departure returns, Δp_s^{LND} and Δp_{s-1}^{LND}:

$$var\left(\Delta p_t^{AMS,news}\right) = cov\left(\Delta p_t^{AMS,news}, \Delta p_{s-1}^{LND}\right) + cov\left(\Delta p_t^{AMS,news}, \Delta p_s^{LND}\right) + \sigma_{w_t}^2, \text{ and}$$
$$var\left(\Delta p_{t+d}^{AMS,no-news}\right) = cov\left(\Delta p_{t+d}^{AMS,no-news}, \Delta p_s^{LND}\right) + \sigma_{w_{t+d}}^2$$

(see Section IV.D for details). The impact of trading costs is identified through simulations of a simple inventory cost model. See Section IV.E and Table XIII for details.

	EIC		BoE		3% ann.	
	$var(\Delta p_t^{AMS})$	% total	$var(\Delta p_t^{AMS})$	% total	$var(\Delta p_t^{AMS})$	% total
Boat returns	0.703		0.229		0.425	
Attributed to:						
Public news	0.380	54.0%	0.129	56.4%	0.202	47.5%
Private information	0.277	39.3%	0.045	19.5%	0.057	13.4%
Trading costs	0	0%	0.049	21.6%	0.105	24.6%
Residual	0.047	6.6%	0.006	2.5%	0.061	14.4%
N	681		681		681	
No-boat returns	0.279		0.131		0.194	
Attributed to:						
Private information	0.110	39.4%	0.051	39.3%	0.051	26.3%
Trading costs	0	0%	0.049	37.7%	0.105	53.9%
Residual	0.169	60.6%	0.030	23.0%	0.038	19.8%
N	481		481		481	
All returns	0.528		0.188		0.330	
Attributed to:						
Public news	0.223	42.2%	0.076	40.2%	0.114	35.9%
Private information	0.208	39.4%	0.047	25.3%	0.057	16.5%
Trading costs	0	0%	0.049	26.1%	0.105	31.8%
Residual	0.097	18.5%	0.016	8.5%	0.047	15.8%
N	1162		1162		1162	

Table XV
Amsterdam Return Reversals and The Arrival of Boats

This table presents additional details on reversal patterns in security returns. It presents coefficients of the regression $\Delta p_t^{AMS} = \alpha_0 + \alpha_1 \Delta p_{t-1}^{AMS} + u_t$ for different scenarios, indicated by $B_{t-1}, B_t \in \{0,1\}$, which indicate whether periods t and $t-1$ featured the arrival of a boat. Reported reversal coefficients are based on equations (9) and (10) and sum up the different interaction effects. Differences in coefficients are indicated with Δ. ***, **, and * indicate whether differences are statistically different at the 1%, 5%, and 10% level, respectively. The statistical tests are based on robust bootstrapped (1000 replications) standard errors that come from estimating (9) and (10).

		(1)	(2)	(3)	(4)
		Current return, Δp_t^{AMS}			
EIC		All	$B_t = 1$	$B_t = 0$	Δ
Previous return,	$B_{t-1} = 1$	0.058	0.193	-0.023	-0.216**
Δp_{t-1}^{AMS}	$B_{t-1} = 0$	-0.117	-0.160	0.067	0.227**
	Δ	-0.174**	-0.353***	0.090	
BoE					
Previous return,	$B_{t-1} = 1$	-0.074	-0.088	-0.063	0.025
Δp_{t-1}^{AMS}	$B_{t-1} = 0$	-0.051	-0.068	0.070	0.139
	Δ	0.023	0.020	0.133	
3% annuities					
Previous return,	$B_{t-1} = 1$	-0.073	-0.042	-0.095	-0.053
Δp_{t-1}^{AMS}	$B_{t-1} = 0$	-0.277	-0.283	-0.181	0.101
	Δ	-0.204**	-0.241**	-0.087	

Notes

[1]Ederington and Lee (1993), Fleming and Remolona (1999), Bollerslev, Cai and Song (2000), and Balduzzi, Elton and Green (2001) focus on the link between news and interest rates, and DeGennaro and Schrieves (1997), Andersen and Bollerslev (1998), Melvin and Yin (2000), Evans and Lyons (2008), and Hashimoto and Ito (2010) focus on the link between news and exchange rates.

[2]This paper is also related to the history of stock market integration. See Garbade and Silber (1978), Hoag (2006), and Sylla et al. (2006).

[3]The Internet Appendix is available in the online version of the article on the Journal of Finance website.

[4]Wilson (1941, Appendices B to D) provides the identities of some of these investors. Most of these individuals also owned stock in the most important Dutch stock of the period, namely, the Dutch East India Company (Dutch National Archives 1.04.02: 7075-7078).

[5]Anecdotal evidence suggests that trade continued outside these official hours in coffee shops and in front of the Jewish synagogue (Van Nierop (1931)).

[6]See for example Hope & Co., Amsterdam City Archives 735: 1510.

[7]For more details see Rotterdam City Archives, OSA 2599.

[8]The famous story that he received this information through a carrier pigeon, a full day before anyone else, is a myth (Ferguson (1998), p. 15).

[9]See Wilson (1941, pp. 74-75), Van Nierop (1931), and Hope & Co, City Archives Amsterdam 735: 78, 79, 115, and 1510.

[10]The SSC was originally founded to transport slaves from Africa to the Spanish American colonies. These activities never materialized and, instead, the company functioned predominantly as an investment vehicle in British government debt (Neal (1990)).

[11]*Amsterdamsche Courant*, February 14, 1778.

[12]There were two minor financial crises in the period. In June 1772 the default of London speculator Alexander Fordyce led to some turbulence in financial markets in London and Amsterdam. Furthermore, after Christmas 1772 a consortium of Dutch bankers who had been bulling the market for English stocks defaulted. This led to a short-lived financial crisis in Amsterdam (Wilson (1941)). Omitting these two episodes does not change the results in an important way.

[13]Neal (1990) uses data reported by Castaing's *Course of the Exchange*. Rogers (1902) uses stock prices reported by various British newspapers.

[14]The use of log rather than simple returns is motivated by the fact that log returns have less kurtosis, which facilitates

the statistical analysis. Results using simple returns are virtually the same.

Note that the three-day period includes the weekend. During the 18th century, trading continued during the weekend. However, trade on Sunday was limited due to the absence of Christian traders. Likewise, Jewish traders did not participate on Saturdays (Spooner (1983), p. 21). Section V.A of the Internet Appendix indicates that there is no evidence for more or less volatility over the weekend. I therefore did not scale the three-day weekend return down.

[15]Note that this period excludes the South Sea bubble of 1720.

[16]See also the London Chronicle, Nov. 18, 1783.

[17]To illustrate, an English freighter ship that tried to reach the Dutch shore on January 6 was blown all the way back to Eastbourne on the English Channel, over a distance of 182 miles (*Rotterdamsche Courant*, February 4, 1776).

[18]I thank Will Goetzmann for this suggestion.

[19]This analysis follows Cutler, Poterba, and Summers (1989), who find that many of the largest 50 daily price changes between 1946 and 1988 are difficult to attribute to specific news events. In a similar vein, Fair (2002) identifies 220 large intradaily price changes between 1982 and 1999, of which only 69 can be attributed to the arival of relevant new information.

[20]Dropping all observations for which the newspaper mentions "stocks" does not change the results.

[21]I discuss the impact of informed in Section IV.D.

[22]This is based on two sources. The first contains trading records of Abraham Cohen de Lara, a Portuguese-Jewish merchant based in Amsterdam (City Archives Amsterdam 334: 722-723). The second contains information on the liquidation of securities pledged as collateral in margin loans (City Archives Amsterdam 5075: 10603-10611).

[23]The Amsterdam EIC return in response to Prime Minister Fox's speech on November 28, 1783 is omitted in all density plots, regression estimates, and variance calculations. The corresponding return of -14% is 18 standard deviations from the mean of the EIC return distribution. If included, this datapoint would largely drive the variance results of the EIC, in which case these results would not be representative of the full sample.

[24]Because the return series are nonnormal (see the kurtosis measures in Table IX), a standard F-test on the equality of variances is not suitable. I follow Boos and Brownie (2004) and use a nonparametric test based on mean absolute deviation from the median. In particular, I use a Brown-Forsythe (B-F) test.

[25]See Table IA.I (definition A) in Section III.A of the Internet Appendix for details.

[26]For modern evidence on the delayed response to public news see Huberman and Regev (2001), Hong and Stein (2007), and DellaVigna and Pollet (2009).

[27]There is one problem with the estimation: Δp_{s-2}^{LND} is not a perfect measure of news because returns in London presumably reflect local liquidity shocks as well. This means that equation (1) suffers from attenuation bias. Specifically, α_2 is biased

downwards. Nevertheless, as long as Δp_{s-2}^{LND} conveys relevant information, the coefficient should still be positive.

[28]This setting can accomodate private information that is longer lived (as long as innovations are iid). The corresponding identification strategy is slightly more complicated and relies on the covariance of Amsterdam returns with returns in London that take place further into the future. Empirically, these are small and add little to the simple analysis presented here.

[29]This is the case in the canonical Kyle (1985) and Glosten and Milgrom (1985) models. In Section VI of the Internet Appendix, I show that the results go through for the more general case in which $cov(\theta_{t+d-1}, \theta_{t+d}) \neq 0$ for $d \in [1, 7]$.

[30]See Biais and Green (2007) for another example where historical trading costs are lower than modern ones.

[31]It is possible that the market's response to information itself may have changed. More advanced information technology could facilitate more efficient information processing. It is not clear that this is the case, however. Bai, Philippon and Savov (2013) show that even after decades of rapid technological progress, markets have not become more informative. In addition, the results of this paper indicate that the Amsterdam market was not slow to respond to information.