The boats that did not sail

Evidence on the sources of asset price volatility from an 18th century natural experiment[1]

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Abstract

How much of short run asset price volatility is due to news on the fundamental value of a stock and how much can be accounted for by non-fundamental factors related to the trading process like mispricing or investors' liquidity? Because trading and the arrival of news tend to come together this question is difficult to answer with modern day data. However it can be approached through a natural experiment provided by the 18th century Amsterdam equity markets. In the 18th century a number of British stocks was traded on the Amsterdam exchange and all relevant price information from England reached Amsterdam through the use of mail boats. This paper identifies periods in which these boats could not sail for reasons related to the weather and analyzes what this lack of information implied for the volatility of the British stocks traded in Amsterdam. Results show that asset price volatility during periods without news was around two thirds of the volatility that is observed during periods with news. This suggests an important role for non-fundamental factors in the day to day movement of asset prices.

1 Introduction

How much of short run asset price volatility is due to news on the fundamental value of a stock and how much can be accounted for by non-fundamental factors related to the trading process like mispricing or investors' liquidity? This question is difficult to answer since trading activity and information flows usually go together. Separating the two effects is extremely difficult as it is impossible to determine when exactly information (be it public or private) reaches the market (Fleming, Kirby and Ostdiek 2006).

The Amsterdam equity market of the 18th century offers an ideal natural experiment to approach this problem. In Amsterdam an active trade existed in the shares of a number of English companies (the East India Company, the Bank of England, and the South Sea Company, Van Dillen 1931 and Neal 1990). It can be expected that normally all relevant information on the fundamental value of these shares originated from London. Not only did the most relevant developments take place there, the main market for the stocks was also in London, generating highly relevant price data Dutch investors could use (see Neal 1990). How did this information reach Amsterdam? Twice a week a mail packet boat left Harwich with 'the English letters' and set its sails for Hellevoetsluys, a small harbour town close to Rotterdam. The English letters contained information on the share price movement of the

[1] I thank Hans-Joachim Voth for guidance and Joost Jonker and Jan Luiten van Zanden for useful comments. Any remaining errors are my own.

British stocks in London and maybe additional information from correspondents or family. This was the main and by far the fastest way information from London could reach Amsterdam (Hemmeon 1912, Ten Brink 1969, Hogesteeger 1989, and OSA 2599).

These packet boats could not always sail. At times there was a strong wind from the east or no wind at all and the packet boats from Harwich would reach Hellevoetsluys with a delay. As a consequence the Amsterdam market was starved from information for a number of days or even weeks. Trading in the English shares continued however. This provides the perfect environment to test the relative influence of news and trading activity on short run price volatility. All price fluctuations that took place after the arrival of news reflected both sources of asset price volatility while price changes in the absence of news were related to trading activity only.

This paper relates to a literature in Finance that tries to empirically explain asset price volatility. In general the literature has identified two main reasons for asset price volatility: (1) the arrival of public and private information about the fundamental value of an asset and (2) factors unrelated to the fundamental value of an asset that are associated with the trading process. Specific examples of such trade induced volatility are investors' liquidity shocks, mispricing and speculation (see Ito, Lyons and Melvin 1998 and Schiller 2001 for an overview). So far most contributions have highlighted the importance of the information channel.

In a seminal contribution, French and Roll (1986) document that price movements are significantly higher during trading hours than during non-trading hours. They explain this with the existence of private information. Private information can only be made known to the market through the trading of informed investors. This implies that if there is no trade, private information will not be used and price fluctuations will be limited. They find little effect of public information flow and pricing errors. A number of studies followed up on this contribution. [ADD REFERENCES AND CONCLUSIONS]. More recently Ito, Lyons and Melvin (1998) analyze the same problem from a new perspective: the Tokyo currency market. In 1994 the lunch hour in the Tokyo currency market was abolished, allowing trading to go on continuously over the day. Ito et al. show that this went hand in hand with an increase in volatility. Looking at intraday volatility the authors argue that this increase in volatility was due to an increased revelation of private information over the day. Finally, Fleming , Kirby and Ostdiek (2006) focus on price volatility in markets that are sensitive to the weather (agricultural and energy markets). They show that the difference in volatility between trading and non-trading periods is smaller in periods in which the weather is more important for the value of commodities. Weather information is updated 24 hours a day and is a public source of information. The smaller difference in volatility is therefore consistent with a big role for public information, driving up non-trading volatility in the weather sensitive seasons.

As mentioned before, it is difficult to separate information flows from the trading process. The generation of information is often endogenous: investors will only invest in private information if they can actually use it. In addition, information flow and trading both tend to occur during the day (Fleming, Kirby and Ostdiek 2006, p. 2900) making it impossible to determine each factor's contribution to volatility. The papers discussed provide evidence for the importance of information flow on asset price volatility but remain silent on the question how important factors unrelated to information flow are. The contribution of this paper is to use a natural experiment provided by history that does allow for the separation of trading and information flow. Consequently it is able to quantitatively asses the individual effects of both factors on asset price volatility. To my knowledge this is the first paper that using such a clean methodology to do this.

An important point to note is that the share price volatility analyzed in this paper was generated in a developed market. This implies that the results found are, to some extent, relevant for today's financial markets. Already in the beginning of the 17th an active trade in shares of the Dutch East India Company (VOC) emerged in Amsterdam (Smith 1939 and Gelderblom and Jonker 2004). Slowly this trade developed further with the introduction of shares of the Dutch West Indies Company (WIC) and around 1700 trade in the shares of the English companies started (Smith 1919, p. 107 and Neal 1987, p. 97). In a very short period Amsterdam grew from a local exchange to an international capital centre, only to loose its dominant position to London after the French invasion of 1794 (Smith 1919, p. 107, De Vries 1976 and Jonker 1996). The sophistication of the Amsterdam stock market during the 18th century was based on two pillars: the efficiency of (a wide range of) transactions and the liquidity of the market

In the 17th a large part of European goods trade was focussed on Amsterdam and the Dutch and the financial techniques Amsterdam merchants had to apply here were easily transferred to the trade in shares. De la Vega (1688, 1939) describes the wide variety of financial instruments already available to the Dutch investor in 1688. Most famous are the put and call options in use, but in general a wide menu of spot and future transactions was available. Smith (1919) shows that in the 18th century the use of financial instruments was fully institutionalized. The existence of specialised groups of brokers ensured that all different types of transactions were handled efficiently. In addition free entry of brokers ensured that no specific group would dominate a certain part of the market. (Jonker 1996, p. 147).

Liquidity of the market was ensured by the huge capital accumulation that took place during the Dutch Golden Age of the 17th century, making the Netherlands (and specifically Holland) an important capital exporter (Carter 1975, De Vries 1976, p. 12-13, Neal 1990). During the 18th century Dutch capitalists invested in a wide range of assets, which included, besides the aforementioned English and Dutch shares, domestic and foreign bonds issued by nearly all European powers (De Vries 1976, Buist 1976, Riley 1980 and Jonker 1996). Only the prices of shares in the main English and Dutch companies and English government bonds were regularly (three times a week) published in the main newspaper, the *Amsterdamsche Courant*, indicating that these shares were most actively traded in the Amsterdam market. The scarce records brokers have left us give the strong impression that an active trade indeed existed in these assets (Van Dillen 1931 and Van Nierop 1931).

The liquidity and efficiency of the Amsterdam market ensure that the findings of this paper reflect the dynamics of a market that, to some extent, resembled today's markets. In his excellent book *The Rise of Financial Capitalism* (1990) Larry Neal has made a strong argument for the efficiency of capital markets in 18th century Amsterdam and London. Using asset price data for the English shares traded in Amsterdam and London he argues that the market, at least for these assets, was efficient. In addition, Neal shows that the Amsterdam and London exchanges were well integrated. News arriving with the packet boats from Harwich made sure that Amsterdam investors were well informed about developments in London. Differences in share prices between London and Amsterdam were small and generally short lived. In general, it was only a matter of days before the asset prices in Amsterdam would reflect recent developments in England.

This paper takes Neal's findings as a starting point and uses the variation in the arrival of news in Amsterdam too tease out the different effects of fundamental information and trading induced factors on short run asset price volatility. This paper finds that the short term volatility of the English shares in Amsterdam can for a large part be attributed to factors unrelated to the fundamental value of these shares. I estimate that between a half and two thirds of volatility can be attributed to non-fundamental factors. These results are robust to corrections for fluctuations in short and long term interest rates. In addition I show that my identification of periods with and without news is correct. More specifically I show that short run price changes in London and Amsterdam were only correlated after the arrival of news. In the absence of news this correlation broke down. I also show that the direction of the flow of news was always from London to Amsterdam. Price changes in Amsterdam lagged and did not lead developments in London.

The rest of the paper is organized as follows. Section 2 discusses the methodology of this paper in more detail. I will explain how the English news reached 18th century Amsterdam and how, from a number of various sources, I can reconstruct quite precisely when this information arrived in Amsterdam. Section 3 presents the estimates of asset price volatility in periods with and without news. Section 4 discusses a number of robustness tests and provides evidence that the identification of periods without news is correct and that information flows relevant for the English shares went in one direction: from London to Amsterdam and not the other way around. Section 5 concludes.

2 Packet boats in the 18th century: a natural experiment

As mentioned in the introduction, a number of English assets was traded on the Amsterdam exchange during the 18th century: the East India Company (EIC), the Bank of England (BOE) and the South Sea Company (SSC). In addition to these three stocks, two English bonds (the three and four percents) were traded as well. This paper focuses on the share prices of the three companies and analyzes what happened with the short term volatility of these prices during periods in which no news was arriving from London. Data on the prices of these shares are available from the *Amsterdamsche Courant*, which reports prices for three dates a week (so with intervals of two or three days). The dates of arrival of news in Amsterdam are reconstructed using a number of sources, most importantly the *Rotterdamsche Courant* which reports the arrival of boats. Based on this I determine which prices contained news from England and which prices did not.

What kind of prices were reported in the *Amsterdamsche Courant*? First of all, share prices were reported in pounds sterling. This is very convenient as this implies that exchange rate fluctuations did not play a role in the volatility of the share prices. Secondly, the prices reported most likely reflected actual transactions and not quotes from brokers. In appendix B

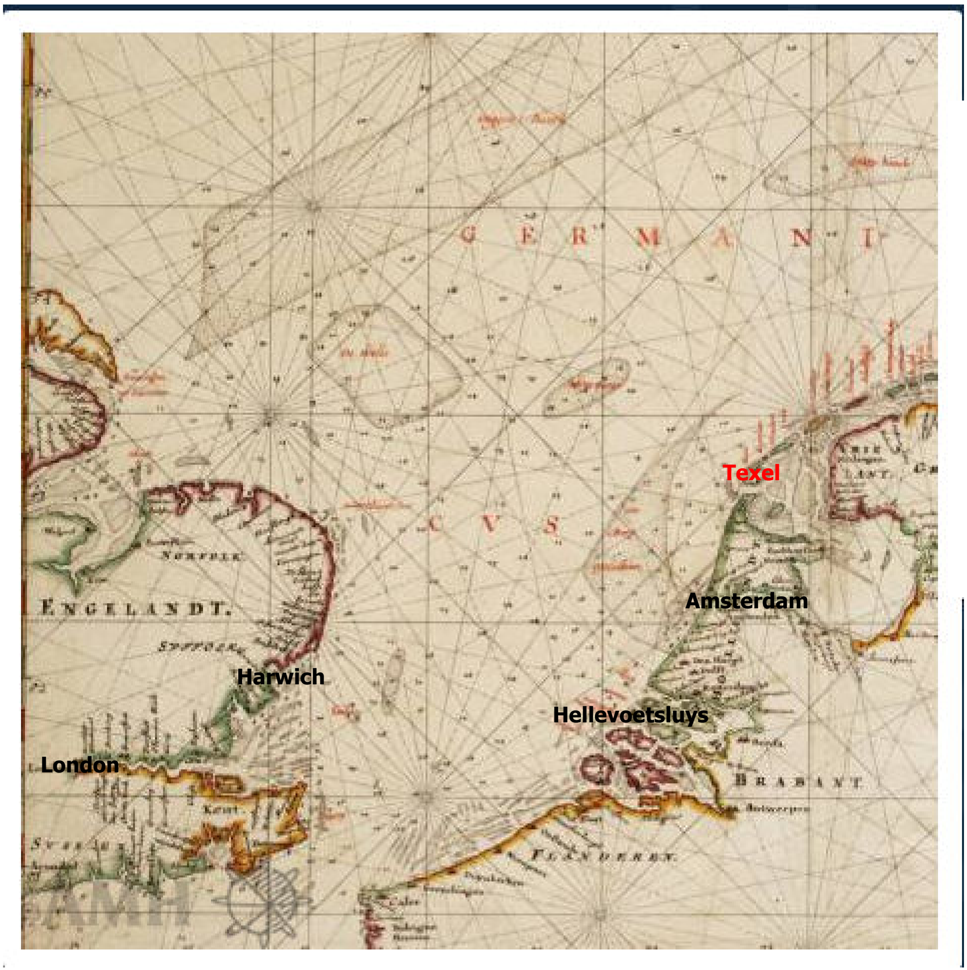
I discuss the reasons why I believe this to be case. Finally, the prices referred to contracts on time. As I describe in appendix B the *Amsterdamsche Courant* reported prices for a kind of future contract in which delivery and payment of a stock was deferred to certain fixed settlement date. This has certain implications for the interpretation of the shares prices, which I will discuss in more detail in section 4.3.

Because of data limitations the period of the analysis is confined to the years from 1771 to 1777. Only in September 1771 did the *Rotterdamsche Courant* start to structurally report the arrival of the packet boats (before this date the newspaper only reported it incidentally). The end date of the sample is determined by a war between England and France that started in February 1778. This war generated information on the continent possibly relevant for the English stocks. The danger exists that this information reached Amsterdam before it reached London, making the experiment unsuitable. I therefore decided to omit all information after 1778 from the sample. In section 4.2 I will elaborate on this point.

How did the English news reach Amsterdam? As discussed in the introduction, a mail packet boat service was organized between Harwich and Hellevoetsluys, bringing in the English letters. This service was set up in 1688 and involved the arrival two boats per week that left Harwich on fixed days. The service was run by the British post (Hemmeon 1912) and in Holland the City of Amsterdam had obtained a monopoly on the distribution of the letters (Ten Brink 1969, Hogesteeger 1989 and OSA 2599). Steamships were not available yet and the packet boats therefore had to rely on wind power. The boats were specifically designed for the trajectory. In 1702 King William III had replaced the existing boats with faster ones. The boats formed the lifeline between England and Holland (apart from letters the boats also transported passengers among which dignitaries and government messengers), and it was of essential importance that they were fast. Not only was it useful if they reached their destinations as quickly as possible, it was also of key importance they would 'out sail' any potential enemy at sea (Hemmeon 1912, p. 115-116). In order to ensure that there was always a boat available to ship the news, four boats were in service. Each boat would sail from Harwich to Hellevoetsluys one week, and in the opposite direction the other week. Given that the average sailing time was around three and a half days, this implied that there was overcapacity. This situation was maintained in order to make sure that when a boat was behind schedule because of adverse wind conditions, the English letters (almost) never had to wait for this. There was always another packet boat in port who could take the shipment.

Figure 2.1 shows how the ships sailed. The English letters were first taken to Harwich by coach. In Harwich they were brought aboard a packet boat that would sail too Hellevoetsluys. In Hellevoetsluys the letters were offloaded and brought to the final destination, again by coach. It is possible to reconstruct quite precisely when news arrived in Amsterdam. This reconstruction is based on three sources: (1) the arrival dates of the packet boats, (2) the average time it took for letters to be transported between Hellevoetsluys and Amsterdam, and (3) the appearance of the English news in the Dutch newspapers. In appendix A I explain the exact methodology in more detail.

Figure 2.1 Route of the packet boats



There was considerable variation in the time it took for the packet boats to reach Hellevoetsluys. On average it took packet boats three and a half days to reach Hellevoetsluys, but in reality it could take anything between one and twenty days. As a consequence English news reached Holland with varying intervals. This variation allows me to compare the volatility of returns in periods with and without news. For the analysis to be completely clean, I need that the sailing time of the boats was unrelated to any other information influencing share prices like political developments. If, for example, boats were delayed because of dangers at sea, sailing times could be potentially correlated with asset prices. My estimates of asset price volatility in the absence of information would therefore be biased upwards. In other words, for my results to be valid sailing time has to be exogenous.

Fortunately this is the case as sailing times were completely determined by the direction of the wind. Table 2.1 illustrates this point. The table presents the average wind direction for the days after departure of a packet boat up to the day that it arrived. So every sailing time corresponds with a row in the table. For brevity I only report the sailing times up to 8 days, as sailing times more than 8 days rarely occurred. The wind direction is reported in degrees, with the North being 360 or 0 degrees, and comes from the observatory of Zwanenburg, a village close to Amsterdam (KNMI).

Table 2.1 Sailing time and wind direction

Sailing time (days)	Wind direction (degrees)								
	N	t+1	t+2	t+3	t+4	t+5	t+6	t+7	t+8
1	4	237							
2	148	244	244						
3	315	246	246	246					
4	140	332	54	99	184				
5	47	112	85	91	98	152			
6	15	101	77	80	79	67	104		
7	8	106	101	95	96	112	117	187	
8	7	166	55	38	83	71	50	148	124

Source: *Rotterdamsche Courant* and KNMI

Figure 2.1 shows that Hellevoetsluys is situated east-to-south (approximately 100 degrees) relative to Harwich. This implies that if the wind was blowing from the same direction, the packet boats would have had serious difficulty in reaching Hellevoetluys. Contemporaries called this contrary wind.[2] If, on the other hand, the wind was blowing from the opposite direction (west-to-north, or 280 degrees) the boats would have reached Hellevoetsluys very quickly. For any intermediate wind direction the boats were probably able to advance, but their speed depended on the exact wind direction.

Table 2.1 shows that this is indeed the case and that the direction of the wind can almost perfectly predict sailing times. Day t+1 is the first day at sea. For short sailing times the wind direction is close to the optimal 280 degrees for all days. For longer sailing times this is not the case. Take a sailing time of 4 days for example. The average wind direction on day t+1 is close to North (not ideal, but not dramatic either), but for t+2 and t+3 the wind blows from the East, preventing the boats from advancing. Only when the wind turns south are the boats able to approach Hellevoetsluys. The same pattern can be observed for longer delays. During the first days wind is blowing from the East, only to change direction on the last day(s) of sailing. Note that the fit between sailing time and wind direction is particularly good considering that these wind directions were measured in Zwanenburg, a couple of hundred kilometers away from Harwich.

The fact that the wind direction plays such a key role in determining sailing times is comforting, but can I be completely sure that other factors, potentially related to asset price movements, did not play any role? I believe I can. There is a specific episode in the history of the packet boats to support my point. On April 30 1777 a privateer sailing under the American Revolutionary flag (in 1777 the United States were still fighting their War of Independence against England) attacks a packet boat and takes over the ship and the English letters. They especially seem to value the latter as, according to an eye witness, they plan to send these letters to Congress[3]. If these events happened more regularly this could be an indication that timing of or the arrival of news was not exogenous but related to, in

[2] 'Contraire wind', *Rotterdamsche Courant*, passim.

[3] 'Dat maal (de brieven) zal niet open gedaan worden voor dat het bij het congres komt', The same article mentions that an English official messenger managed to throw the letters he carried with him over board. *Rotterdamsche Courant*, May 3, 1777.

this case, international political tensions! Fortunately, this incident seems to have been a very rare event. The *Amsterdamsche Courant* reports that, as far as anybody can remember, this is 'only the third time a ship has been taken over by enemies[4]'. At least for the years between 1771 and 1777 I did not find any evidence that these type of threats influenced the sailing times of packet boats at any time except for this incident. For most of the time the wind direction seems to have been more important.

3 The sources of asset price volatility

Based on reconstruction of the dates on which news arrived in Amsterdam I can determine when the share prices of the English Companies in Amsterdam contained new information and when they reflected the same information as the previous price. Based on this I construct returns and I separate the sample of returns in two groups, one with news and the other without.

The return[5] on asset i (R_{it}) can be attributed to two parts:

$$R_{it} = P_{it} - P_{it-1} = f\left(F_{it} - F_{it-1}, NF_{it} - NF_{it-1}\right) = f\left(\Delta F_{it}, \Delta NF_{it}\right) \quad (3\text{-}1)$$

The first part, ΔF_{it}, reflects the arrival of news from England and can be considered a change in the information investors available on the fundamental value of he share in England. This can be news on the political or economic situation in England (a specific speech in Parliament relevant for the English debt position or the arrival of a fleet from India), or it can simply be the most recent price of a share on the English market. The second part, ΔNF_{it}, reflects the change in non-fundamental factors that are related to the trading process. Ito, Lyons and Melvin (1998) name a number of different types of non-fundamental factors. First of all there is mispricing. Some market participants may not be fully rational and it may take time for rational investors to step in and bring prices back to fundamentals (Delong et al. 1991). In addition certain speculative factors (think of the dynamics of a bubble) could affect prices. Apart from these mispricing concerns micro market structure could also have the effect that asset prices deviate from their fundamental value. Risk aversion of investors with respect to a certain stock can vary (for example because of inventory risk), traders can face certain constraints (for example having to sell because of private liquidity shocks) and there can be other factors related to a change in the supply or distribution of an asset that affect its price.

Depending on whether or not news arrives at time t returns with or without news can be written as follows.

$$R_{it}^{NEWS} = f\left(\Delta F_{it}, \Delta NF_{it}\right) \quad (3\text{-}2)$$

[4] 'Zo ver men zig herinnerd is het de 3en paketboot die ooit door eenig vyand tusschen Harwich en Helvoet genomen is', *Amsterdamsche Courant*, May 6, 1777.

[5] Because the *Amsterdamsche Courant* reports shares prices with intervals of two or three days, these returns are either two day or three day returns.

and

$$R_{it}^{NONEWS} = f(0, \Delta NF_{it}) \tag{3-3}$$

Assuming that the function $f(\;)$ is separable in ΔF_{it} and ΔNF_{it} and that these two variables are uncorrelated (both contemporaneously and over time), these expressions can be simplified to calculate the relative contributions of both factors to total asset price volatility:

$$VF_i = \frac{V(R_{it}^{NEWS}) - V(R_{it}^{NONEWS})}{V(R_{it}^{NEWS})} = 1 - \frac{V(R_{it}^{NONEWS})}{V(R_{it}^{NEWS})} \tag{3-4}$$

and

$$VNF_i = \frac{V(R_{it}^{NONEWS})}{V(R_{it}^{NEWS})} \tag{3-5}$$

with VF_i the return variance that can be attributed to the arrival of news and VNF_i the return variance that can be attributed to non-fundamental factors.

The above exercise was performed on the return data (three observations a week) of the EIC, the BOE and the SSC between September 1771 and December 1777. Before moving forward to these results, let me first present the distributions of returns of the three companies in figures 3.1a to 3.3b to provide some intuition about the data.

Figure 3.1 Return distributions EIC

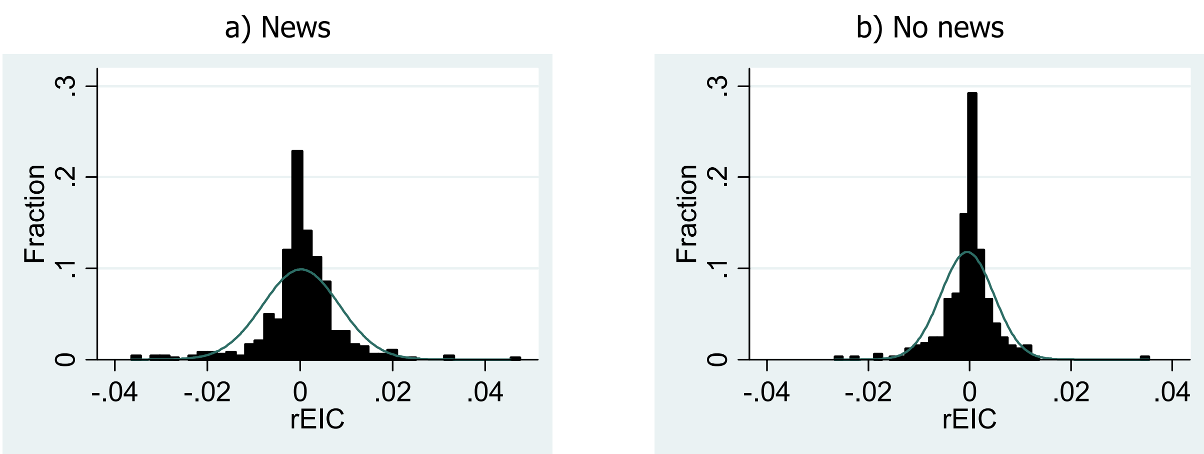


Figure 3.2 Return distributions BOE

a) News b) No news

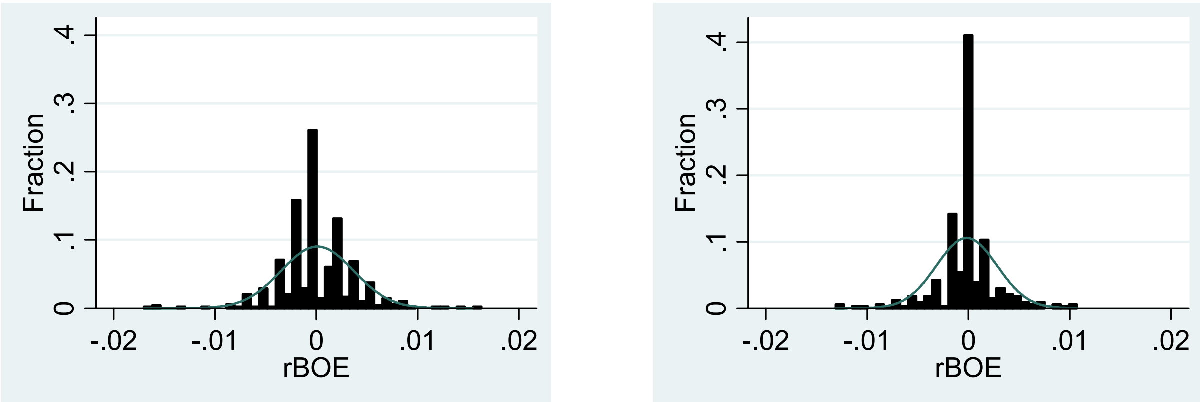
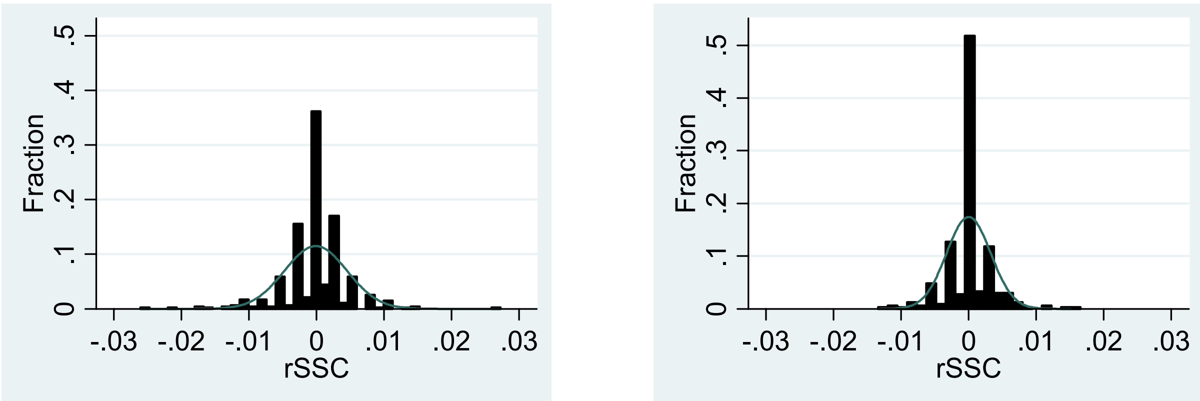


Figure 3.3 Return distribution SSC

a) News b) No news



Horizontal axis presents returns in fractions. The thin line represents a theoretical normal distribution with mean and stand deviation from the sample.
Source: *Amsterdamsche* and *Rotterdamsche Courant*, September 1771 – December 1777

The first thing to note from these graphs is that the distributions of the returns with news are wider than those without news. For example, most of the probability mass of the EIC returns with news lies between -1.5 and 1.5 percent, while most returns without news lie between -1 and 1 percent. In addition the fraction of zero returns is far lower for returns with news. Both observations point to the fact that the volatility of returns is higher with than without news. This is consistent with what has been discussed so far. Another thing to note is that, as is usual with daily stock returns, the return distributions are non-normal. There is a lot of mass in the tails (excess kurtosis) and relative to the normal distribution there are too many zeros. The distributions resemble a Laplace or double exponential distribution. This means that the standard deviation is a very poor statistic to capture the underlying volatility. The normal distributions drawn in the histograms of figures 3-1a to 3-3b illustrate this point. The standard deviation of BOE returns is for example more or less the same with and without news, while it is evident that the BOE returns with news are more widely distributed.

An alternative summary statistic that suffers less from these problems is the average absolute deviations from the mean. More formally, the summary statistic for volatility I use is defined as

$$V(R_{it}) = \frac{1}{T}\sum_{T} abs(R_{it} - \overline{R}_i) \tag{6}$$

with $\overline{R}_i$ the mean return of stock i. Table 3.1 presents this volatility measure for the three funds, broken down for returns with and without news. In addition, the table presents estimates of the relative contributions of information and trade related factors to total volatility as defined in equations (3-4) and (3-5).

Table 3.1 Estimates of return volatility

	$V(R_{it}^{NEWS})$	N	$V(R_{it}^{NONEWS})$	N	VF_i	VNF_i
EIC	0.0053	481	0.0032	331	0.39	0.61
BOE	0.0025	480	0.0020	329	0.21	0.79
SSC	0.0030	476	0.0020	329	0.31	0.69

Table presents volatility estimates of returns based on the average absolute deviation from the mean. Returns are calculated according to equation (3-1) and are in fractions.
Source: see figures 3.1-3.3

The table reveals that the relative contributions of information and non-fundamental factors to overall volatility differ for each stock. However for all three companies non-fundamental factors dominate information: the contribution of factors unrelated to information lies between 61 and 79 percent. Although the arrival of news has an important influence on returns, short run volatility is for the largest part driven by factors related to the trading process.

The statistical significance of these results can easily be evaluated by regressing the returns' absolute deviations from the mean, $abs(R_{it} - \overline{R}_i)$, on a constant and a dummy variable indicating whether a return contains new information or not. For all three stocks the difference in volatility is statistically significant at very high confidence levels. In addition, the differences in volatility are robust to the inclusion of month dummies, the day of the week and a time trend (results available upon request).

The identification of the arrival of news in Amsterdam is based on a number of assumptions on how much time it took for news to travel between Hellevoetsluys and Amsterdam (see appendix A for details). If these assumptions are wrong it is possible that some of the returns I have identified as including no news, actually did reflect news from London. Or alternatively, returns I identified as containing new information may not do so in reality. Both identification errors could create an upward bias in estimating the fraction of return volatility that can be attributed to non-fundamental factors. Although I will show in section 4 that my identification strategy is valid in general, it is possible that in some individual cases it fails. To evaluate the possible bias arising from this I redo the calculations of table 3.1 with a more conservative identification strategy of the arrival of news. Only the returns are used of which I can be absolutely sure that they do or do not contain information brought in by the packet boats. Unfortunately, this stricter definition implies a *de facto* reduction in the sample size (see appendix A for details). Results are reported in table 3.2.

Table 3.2 Estimates of return volatility, conservative definition

	$V\left(R_{it}^{NEWS}\right)$	N	$V\left(R_{it}^{NONEWS}\right)$	N	VF_i	VNF_i
EIC	0.0060	273	0.0032	191	0.47	0.53
BOE	0.0026	272	0.0019	189	0.26	0.74
SSC	0.0028	270	0.0019	191	0.33	0.67

Table presents volatility estimates of returns based on the average absolute deviation from the mean. Returns are calculated according to equation (3-1) and are in fractions. Sample confined to returns of which it is absolutely certain that they contained news or not.
Source: see figures 3.1-3.3

From table 3.2 it becomes clear that using a more conservative identification strategy changes results quantitatively: now between 53 and 74 percent of volatility is unrelated to the arrival of news. This change is solely caused by the estimates of $V\left(R_{it}^{NEWS}\right)$, the volatility of returns in the absence of news is hardly any different. Qualitatively conclusions are unaltered: a large fraction of volatility is caused by factors unrelated to news.

4 Robustness checks

In order to truly believe these results, there are a number of open questions to be questioned. First of all, is it really truly that no news arrived in Amsterdam if the packet boats were not sailing? Were there no alternative channels through which the English news could reach Amsterdam? Secondly, is it really true that the direction of news was always from London to Amsterdam and not the other way around? Are there no cases in which Dutch investors got relevant price information before their English counterparts? Finally, to what extent is volatility in the absence of news not simply caused by changes in the interest rate? In this section I will address these three questions in a rigorous manner and I will show that the main conclusions from this paper are robust to these considerations.

4.1 Possible alternatives to the packet boat

The packet boats formed the only official mail service with England. Together with the City of Amsterdam, the British post was granted the monopoly to ship letters between Holland and England and any competition from other persons or organizations was deemed illegal (Ten Brink 1969, p. 24 and OSA 2599). Most evidence suggests that the English letters carried by the packet boats were indeed the main source of English information for the Dutch public. The Dutch newspapers' reports on England were based on the English letters and there is an example of an Amsterdam broker specializing in English shares that explicitly referred to them in the letters to his customers (Van Nierop 1931). The *Rotterdamsche Courant* was also very dedicated in reporting the arrival of the packet boats, indicating the importance of the mail service for its readers.

Note that there each week several ships (especially cargo ships and fishing boats) sailed between Holland and England. However none of them could have shipped English news to Amsterdam as quickly as the packet boats did. Figure 2.1 shows that Harwich – Hellevoetsluys was one of the most direct connections between London and Amsterdam, especially if one considers that boats could not reach Amsterdam directly but had to sail via the island of *Texel*, taking several days extra. It is important to note in this respect that it was the City of Amsterdam who set up the packet boat service in 1688. They made sure that the news would take the fastest route as possible (Ten Brink 1969 and Hogesteeger 1989). As mentioned before, the boats were specially designed for their task and were quite quick. In addition the captains sailing the boats did so for tens of years in a row, probably giving them great expertise adding to the efficiency of the system (Hemmeon 1911 and *Rotterdamsche Courant*). Once in Hellevoetsluys the English letters were quickly taken up in the Dutch mail system (for more details see appendix A). Coaches would wait for the boats to bring the letters to their respective destinations as quickly as possible. Taking all these things into consideration, it is far from clear how an individual (or group of individuals) could have obtained the English news through alternative channels. The packet boat system was fast and efficient and organizing a similar or faster scheme would have been very costly.

Speculative gains, however, could have been big and it is possible that at some times other boats brought in information from England. Actually there are some hints that people used fishing boats to get news from England (Smith 1919, p. 107). Fortunately this is not necessarily a problem. The identification strategy of this paper is based on variation in sailing times, creating windows of time during which no news arrived. As I argued in section 2, this variation in sailing time was largely determined by the direction of the wind. Specifically, if the wind was blowing from the east, packet boats took longer to reach Hellevoetsluys. The key thing to note is that other boats would have faced similar delays. From the *Rotterdamsche Courant* it becomes clear that if the packet boat could not arrive, other boats from England did not arrive either. The packet boats even seem to have outperformed other boast: in storms or other types of bad weather, the packet boats were the first to get through. Take for example January 1776, a month of very foul weather with wind blowing almost continuously from the east. Almost no ships managed to reach Holland. On February 4 1776 a certain Captain Gerbrands finally arrived in Hellevoetsluys, having departed London already on January 5. According to the newspaper, his ship had been blown completely of course all the way down south to Beachy Head (East Sussex, south of Dover) and it had taken weeks for it to fight its way back to Hellevoetsluys.[6] In this period, the arrival of packet boats was highly irregular as well, but none of them took as much as 30 days to sail across the North Sea!

One could argue that news did not necessarily have to come by boat. The telegraph was not use yet, but post pigeons could have been used to get the news across the North

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[6] 'Kapt Klaas Gerbrands van London na Terveer bestemd, meldt dat hy den 4 january van Gravesend afgezeild, den 5 in zee en den 6 te Helvoet voor de wal is geweest, doch door de contraire wind terug gedreven was tot de de Vlaamsche Banken; dat hij den 9 dito weder voor Wal was geweest, maar niet binnen konde komen en op zee gedreven is to Bevezier (Beachy Head), den 20 voor Schouwen, den 23 voor Walcheren, alwaar hij ook niet binnen konde komen, en liep op Zee omtrent op 11 vaam ten anker, heeft aldaar 7 dagen gelegen en is van daar tot voor de Goeree vertrokken, en eergisteren met behulp van 2 Yssloepen in de haven gebragt.' *Rotterdamsche Courant* February 4 1776.

Sea. However, this can have hardly played a role. Although the use of post pigeons was already known in Ancient Greece, only around 1800 did people start to train them to make regular mail service possible ([CHECK SOURCE]). The first pigeon post service in the Netherlands I encountered in the literature was set up around 1850 to bring news from Antwerp to Rotterdam (Ten Brink 1957). It is interesting to note that during the winter months this post pigeon service did not operate. Apparently the birds did not cope well in bad weather. This is an indication that, even if post pigeons were used incidentally in the 18th century, they would have faced similar problems as the packet boats.

To summarize, based on the qualitative evidence available it seems unlikely that news could have reached Amsterdam in any other way than the packet boat. This claim can be supported by quantitative evidence. Larry Neal has very generously made his data on daily share prices in London available. Combining my data with his dataset it is possible to compare the price development of the British shares in Amsterdam and London. Suppose there are three dates, $t-1$, t and $t+1$ for which asset prices in Amsterdam are available. Further suppose that both at $t-1$ and $t+1$ news arrives from London containing the most recent share prices in London from a few days earlier at $t-1*$ and $t+1*$ (an asterisk indicates a date in London). If the packet boats were the only channel of information between England and Holland, there are two testable hypotheses. First of all the return in Amsterdam between $t-1$ and $t+1$ should be strongly correlated with the return in London between $t-1*$ and $t+1*$. The latter can be interpreted as the change in investors' information set between $t-1$ and $t+1$. Secondly, the return in Amsterdam between $t-1$ and t should be uncorrelated with the return in London between $t-1*$ and $t*$. Essentially the test here is on whether the information set of investors stays constant between $t-1$ and t, or whether English information from date $t*$ manages to reach Amsterdam through an alternative channel.

Both hypotheses can be easily tested if the relevant dates in London are known. $t-1*$ and $t+1*$ are very straightforward to determine. Apart from reporting the arrival of packet boats, the *Rotterdamsche Courant* also gives information on the date of the English letters brought in by the boats. The problem is in determining $t*$. By definition this date is unobservable as there is no information available from any alternative channel. To determine $t*$ I assume that any alternative way of transportation would take more or less the same time as the packet boat would. Because of the weather, this differs for each season. I therefore calculate the average number of days x it takes for the official English letters to reach Amsterdam for each month separately. $t*$ is then defined for each month differently as $t-x$.

Figures 4-1a to 4-3b present the scatter plots testing the two hypotheses for each stock separately. The left hand panels present the relation between Amsterdam returns with news (between $t-1$ and $t+1$) and the corresponding returns in London (between $t-1*$ and $t+1*$). The right hand panel presents the relation between Amsterdam returns without news (between $t-1$ and t) and the hypothetical returns in London (between $t-1*$ and $t*$). Table 4-1 presents the same relations using formal regression analysis. From both the figures and the table it becomes clear that both hypotheses hold. Returns in Amsterdam and

London are significantly correlated when news is coming in. However this correlation disappears when no packet boat arrives: relative to the situation in which news is arriving, both the coefficient and its statistical significance are considerably smaller.

Figure 4.1 EIC, co-movement London-Amsterdam

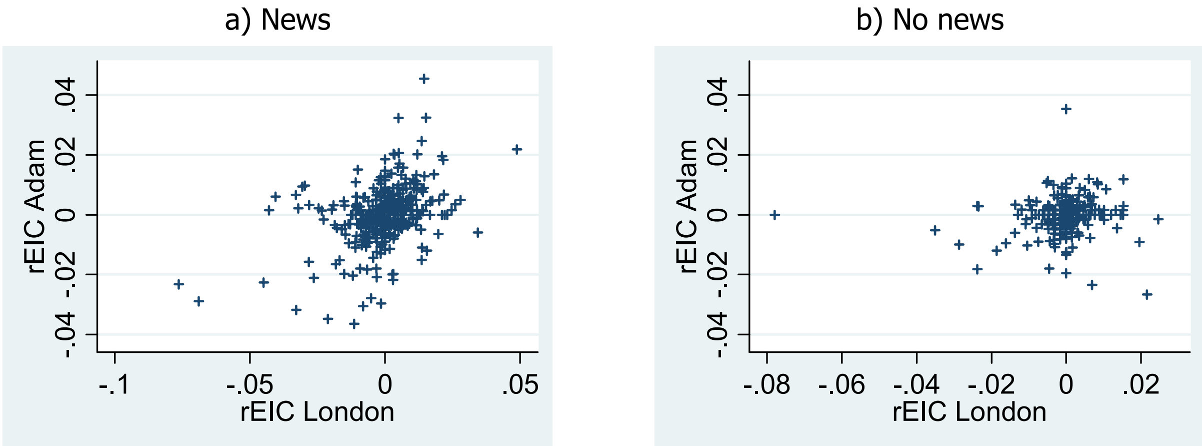


Figure 4.2 BOE, co-movement London-Amsterdam

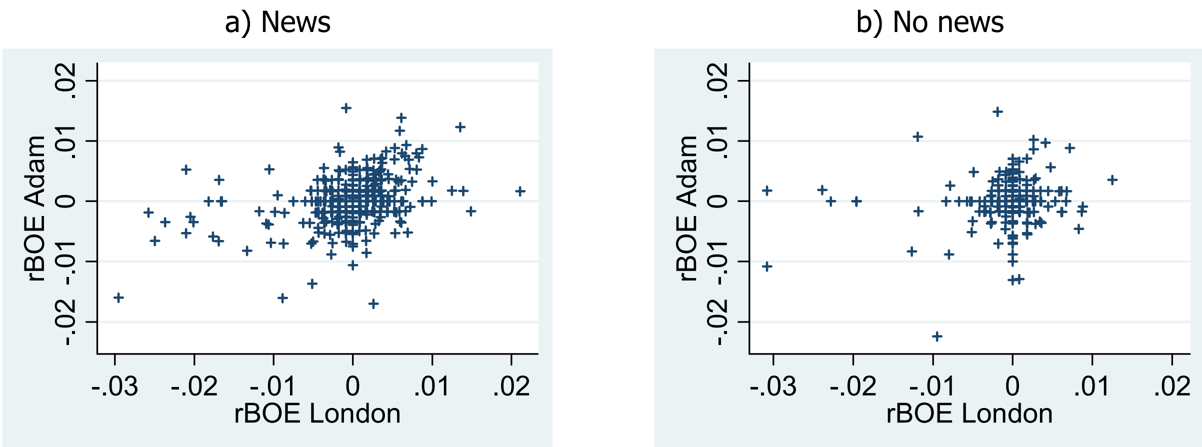
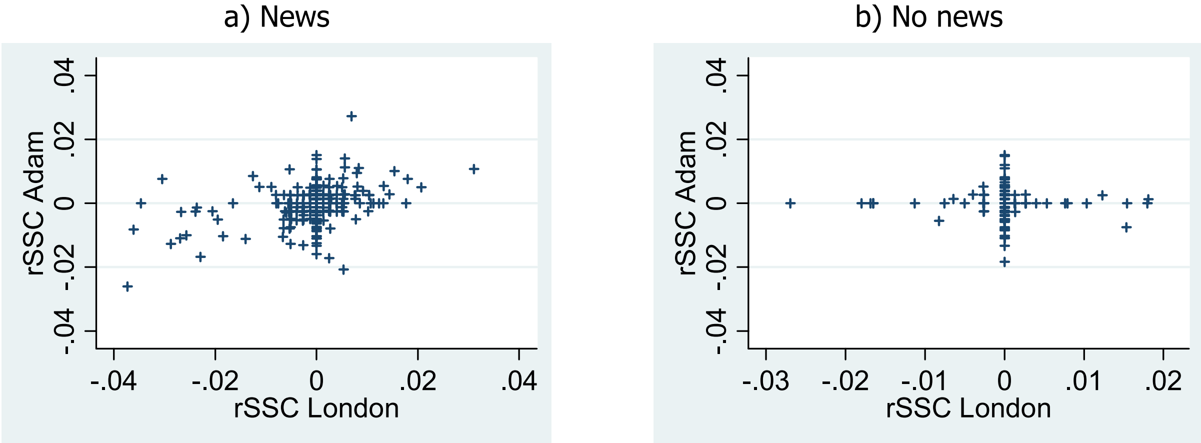


Figure 4.3 SSC, co-movement London-Amsterdam



Horizontal axis represents percentage returns in London, the vertical axis percentage returns in Amsterdam. Both are in fractions.

Sources: *Amsterdamsche Courant*, *Rotterdamsche Courant*, September 1771 – December 1777 and Neal (1990).

Table 4.1 Co-movement returns Amsterdam-London

	Amsterdam return					
	EIC		BOE		SSC	
	news	no news	news	no news	news	no news
London return	0.3090 (0.0000)***	0.0650 (0.2480)	0.2520 (0.0000) ***	0.1090 (0.1300) ***	0.2660 (0.0000) ***	-0.0120 (0.7310)
Constant	0.0000 (0.3140)	0.0000 (0.1630)	0.0000 (0.3630)	0.0000 (0.6110)	0.0000 (0.8540)	0.0000 (0.8180)
R2	0.16	0.01	0.13	0.02	0.12	0.00

Results from regressing Amsterdam on London returns for periods with and without news. London returns are lagged by the number of days it took for the English letters to arrive in Amsterdam. P-values based on robust standard errors reported in parentheses.

*** significant at the 1% level

Sources: see figures 4-1a – 4-3b

Note that it is not surprising that the coefficients from the news arrival case are not close to one. Figures 4-1a to 4-3b show that the mass of the scatter plots lies around the 45 degree line. The changes in prices are just relatively widely dispersed because of fluctuations in non-fundamental factors, leading to attenuation bias. To summarize, the quantitative evidence supports the qualitative information: apart from the packet boat there does not seem to have been an alternative channel through which English news could have reached Amsterdam.

4.2 The direction of news

Another assumption important for the methodology of this paper is that all relevant price information originated from London. This is also something that can be tested rigorously by comparing the share prices in London and Amsterdam. A short description of each company and the time period concerned in this paper can help to better asses these results that will be reported later.

The East India Company held large, continuously expanding possessions in South-Asia and made considerable profits from the trade in Colonial wares. During the early 1770's a debate in Parliament raged on about the influence the English government should have on the company and how much of its profits it was entitled to (Sutherland 1952). Price relevant information on the EIC was therefore related to three things: the produce brought from India, military developments in India and domestic developments in English politics. All three types of news can be expected to have originated in London or have reached London first. There is a slight probability that some news might have reached Amsterdam first. The Dutch East India Company (VOC) and the EIC were competing for influence and products in Asia. It is possible that news of specific English victories/losses reached Amsterdam first.

The Bank of England (BOE) and the South Sea Company (SSC) were both set up to help finance British Government debt. The BOE was set up in 1694 to function as the government's banker. Its function was to supply the government with loans that were financed with equity, deposits and later note issues. In addition, the bank endeavored in the discounting of bills, but on a relatively small scale (Roosegaarde Bisschop 1896 and Clapham 1944). The SSC was set up in 1711 and originally had the purpose to transport slaves from Africa to the Spanish American colonies. However its role in these ventures was rather limited as from 1713 on the Company was involved in several schemes to transfer illiquid British debt into liquid shares (debt for equity swaps). These schemes resulted in the famous South Sea bubble of 1720 (see amongst others Neal 1990 and Temin and Voth 2003). After the bubble burst the SSC continued to exist until 1850 and mainly functioned as an investment vehicle in British Government debt. To summarize, both the BOE as the SSC were mainly involved in British government debt. News relevant for the price of these two stocks can therefore be expected to have originated from London. Only is case of war could price relevant information have reached Amsterdam before London.

This last point has important implications for the period of this study. Not all time periods are suitable for the analysis presented here. The 18th century was filled with European continental wars and England was involved in nearly all of them (Neal 1990). Given that Amsterdam was (effectively) closer to places on the continent it is possible that price relevant news would have reached Amsterdam before London. Taking this and certain data limitations into consideration, the period of the analysis starts in September 1771 (the month the Rotterdamsche Courant starts listing the arrival of the Harwich packet boat) and ends in December 1777 (in February 1778 England became involved in a war with France).

During these periods I am confident that all relevant information originated in London. Between 1771 and 1777 two distinct developments had a big influence on asset price volatility. In both cases all relevant originated from London. First of all in 1772 a huge fall in the price of EIC stock occurred. The EIC had gained significant territorial gains in the second half of the 1760's and this raised the hopes that profitability of the company would rise. The directors of the EIC played into these hopes by overestimating revenues and paying out too much dividends. As a consequence share prices climbed very quickly (Sautijn Kluit 1865 and Clapham 1944). In reality the company was not doing so well, witnessed by a huge famine in Bengal in 1769/70. The directors tried to hide the effects of the famine on the company and continued to pay out high dividends. They were able to continue doing so until 1772 when the bomb burst. In the spring of that year the EIC had to repay a short term loan from the BOE and it failed to do so, having to postpone payments. The bad state of the company was revealed and share prices dropped dramatically (from 227 to 170 percent) (Sutherland 1952).

Another event heaviliy influencing share prices in this period was the American War of Independence that started in 1775. It is well known that this war had a big impact on the English government. As a consequence the price of English debt (and related stock like the BOE and the SSC) fell in value. The important point here is whether news from America would reach Amsterdam directly or through London. It is likely that all American news came through London. Officially there was no news service between Holland and America. Traditionally, all news relating to the America's came from London (Ten Brink 1969, p.22). In addition, close inspection of the Dutch newspapers of the period indicates that all America related information came from London. Usually news on America was reported in the London column. In the case there was a separate column telling the news from America, this always went together with a column reporting the English news, suggesting that both news reports came in at the same time, most likely originating from one and the same place: London.

These claims can be very easily tested by taking a closer look at the data. If all news originated from London, Amsterdam prices should lag London prices with a delay consistent with the time it took for the English letters to reach Amsterdam: on average a period of four days. Neal (1990) already presented evidence on this, showing that Amsterdam prices in general lagged London prices by three days. In this section I redo his analysis focusing on the period September 1771 – December 1777 and looking at return instead of prices.

As I mentioned before, for the Amsterdam market three prices are reported each week: for Monday, Wednesday and Friday. Based on these prices, returns are calculated for two (Fri-Wed and Wed-Mon) or three day periods (Mon-Fri). For the same intervals, the returns in London can be computed. These London returns are then lagged or forwarded and related to the Amsterdam returns. Table 4.2 reports the results from simple uni-variate regressions of Amsterdam on London returns, lagged or forwarded a number of periods.

Table 4.2 The relation between Amsterdam and London returns: different lags and leads.

	EIC		BOE		SSC	
	rLondon	R2	rLondon	R2	rLondon	R2
L8	0.0207 (0.3539)	0.00	-0.0094 (0.5810)	0.00	0.0514 (0.0024)***	0.00
L7	0.0709 (0.0575)*	0.01	0.0387 (0.1902)	0.00	0.1988 (0.0004)***	0.04
L6	0.1644 (0.0006)***	0.03	0.0967 (0.0226)**	0.01	0.1548 (0.0088)***	0.03
L5	0.3241 (0.0000)***	0.13	0.2242 (0.0000)***	0.07	**0.2146** **(0.0005)*****	**0.06**
L4	**0.3527** **(0.0000)*****	**0.15**	**0.2777** **(0.0000)*****	**0.11**	0.1188 (0.0285)**	0.02
L3	0.3092 (0.0000)***	0.12	0.2519 (0.0000)***	0.09	0.2136 (0.0019)***	0.05
L2	0.3327 (0.0000)***	0.13	0.1787 (0.0013)***	0.04	0.1046 (0.0589)*	0.01
L1	0.1988 (0.0000)***	0.05	0.0657 (0.0915)*	0.01	0.0598 (0.1403)	0.00
Current	0.0754 (0.0932)*	0.01	-0.0077 0.5627	0.00	0.0870 (0.0172)**	0.01
F1	0.0355 (0.2576)	0.00	0.0000 (0.4997)	0.00	0.0833 (0.0107)**	0.01
F2	0.0235 (0.3042)	0.00	-0.0083 (0.5687)	0.00	0.0835 (0.0123)**	0.01
F3	0.0074 (0.4314)	0.00	0.0451 (0.1091)	0.00	0.0409 (0.1715)	0.00
F4	0.0367 (0.1290)	0.00	0.0568 (0.0710)*	0.00	0.0332 (0.2309)	0.00
F5	-0.0127 (0.6246)	0.00	0.0396 (0.1623)	0.00	-0.0192 (0.6389)	0.00
F6	0.0158 (0.3440)	0.00	0.0374 (0.1440)	0.00	-0.0001 0.5006	0.00
F7	0.0112 (0.3843)	0.00	0.0283 (0.2140)	0.00	-0.0083 (0.5859)	0.00
F8	0.0111 (0.3976)	0.00	-0.0105 (0.6043)	0.00	0.0495 (0.0575)	0.00

Number of observations: 801.

Coefficients presented are from uni-variate regressions of Amsterdam returns on London returns (for the same time window, see text) lagged (L) or forwarded (F) a number of days.

P-values calculated from robust standard errors reported in parentheses. Coefficients significant at the 1% level shown in grey. The maximum coefficient for each stock in bold.

*** Significant at the 1% level ** Significant at the 5% level ** Significant at the 10% level

Source: *Amsterdamsche Courant*, September 1771 – December 1777 and Neal (1990)

The table clearly shows that for each stock London returns explain Amsterdam returns with a lag, not a lead. This is evidence for the interpretation that price relevant information had its origin in London. In general all lags (from 1 to 8 days) have some impact, but the biggest effect is found by lagging the London return four or five days. The economic effect is considerable. For the EIC, for example, a one percent return in London is associated with a 0.35 percent return in Amsterdam four days later. A lag of four days is consistent with the average time it took for the English letters to arrive in Amsterdam. On average it took the packet boat three days to reach Hellevoetsluys, and the coach service to Amsterdam took another day (see table 2.1 and appendix B).

There are number of points that deserve further attention. First of all, when the London returns are lagged only a small number of periods (one or two days), they still significantly explain returns in Amsterdam. Does this imply that some information could reach Amsterdam faster than the official English letters did? Fortunately the answer is no. Note that the London returns are calculated over the same period as the Amsterdam returns: i.e. two to three days. This implies that the lags presented here include information that goes further back than the lag length. For example the London return lagged for 2 periods includes price information up to five days in the past. A second point that merits fuller explanation is the fact that the London returns on SSC shares forwarded one or two periods have a statistically significant effect on Amsterdam returns. Although the economic effect of the leads is small compared to the lags, this implies that at least some relevant price information for the SSC was generated in Amsterdam and subsequently flowed to London. This can be explained by the fact that in the 1770's SSC stock was probably traded more actively in Amsterdam than in London. No volume data is available, but the prices reported for the Amsterdam and London market were both transaction prices (see appendix B) and the frequency at which they are reported are an indication of trading activity. Based on the price data it seems that there was always at least some activity in SSC shares in Amsterdam, whereas in London weeks could pass without any transaction. If the SSC stock was indeed more actively traded in Amsterdam, this would imply that circumstances specific to the Amsterdam market like investors' liquidity, risk aversion or discount factors could be relevant for the price formation in London. Table 4.2 shows that the size of this effect was small. The size of the coefficients on the forwarded London returns is about a third of the size of the lagged coefficients. Just as with the other stocks, the information flow from London to Amsterdam was most important.

4.3 The influence of interest rates

So far I have provided evidence that (1) the packet boat was the only channel through which news from England could reach Amsterdam and (2) that in general price relevant information had its origin in London and not in Amsterdam. These two pieces of evidence support the interpretation that the part of asset price volatility that I ascribed to non-fundamental factors is really due to factors unrelated to information flows. What these non-fundamental factors are exactly remains an open question. In this paper I will remain agnostic about their exact nature, but I will try to determine the role of one essential thing: interest rates.

As described in the introduction, the prices reported in the *Amsterdamsche Courant* are of time contracts. In appendix B I argue that these time contracts can be priced in a way similar to nowadays futures. I derive the following relation between time and spot prices:

$$TP_{it} = SP_{it}\left(1+r\right)^{T-t} \qquad (4\text{-}1)$$

where TP_{it} is the price on time of asset i at time t, SP_{it} is the spot price and T is the settlement date. This expression includes the short term interest rate r. This implies that volatility in the absence of news could for some part be caused by fluctuations in the short term interest rate. Unfortunately, no interest rate series is available for a frequency similar to the data on the share prices (See Flandreau et al. 2006 for data with a frequency of 2 weeks).

However, there is an indirect way to determine their influence. In appendix B I explain that time contracts were settled every three months during fixed periods, the so-called *rescontres*. The *Amsterdamsche Courant* always reported the price of a time contract to be settled during the next settlement period. This means that the times until settlement of the contracts reported always lie between 1 day and three months. According to equation (4-1), the multiplying effect of the interest rate is the smallest when the time to settlement is the shortest. This implies that if interest rate fluctuations have a significant impact on overall volatility, the volatility of returns should be higher in periods further away from the settlement period. This can be easily tested. Table 4.3 reports the volatility of returns without news for the three weeks with the longest time to settlement and the three weeks with the shortest time.

Table 4.3 Return volatility for different times to settlement

	EIC		BOE		SSC	
	A	B	A	B	A	B
$V\left(R_{it}^{NONEWS}\right)$	0.0032	0.0027	0.0015	0.0019	0.0021	0.0022
N	79	89	77	89	79	88

Columns A report volatility of returns without news for the three weeks with the longest time to settlement. Columns B report volatility for the weeks with the shortest time.
Source: see figures 3-1a to 3-3b.

The table clearly shows that the difference in volatility between the two different regimes is negligible. Differences are generally small and do not exhibit any structural pattern across stocks. For the EIC return volatility is higher the further away settlement is, but for the BOE and the SSC the reverse holds. This is strong evidence for the interpretation that fluctuations in the short term interest rate do not matter for return volatility. These results are robust to the use of different periods (results available upon request).

Another, more obvious, potential cause for short term return volatility is the long term interest rate. A change in the long term interest indicates that investors will discount future dividend payments in a different way: leading to different asset prices. The data provides a simple way to test the influence of interest rates. Apart from the three English companies, the *Amsterdamsche Courant* also reported the prices of the 3 percent English annuities traded in Amsterdam. When there was no news coming in, changes in the price of the 'threes' reflected, apart from certain non-fundamental factors, changes in the long term interest rate. Under the assumption that non-fundamental factors influencing the 3 percent annuities are uncorrelated with the non-fundamentals affecting the EIC, BOE and SSC, the returns on the 'threes' can be used to approximate changes in the long term interest rate[7]. More specifically, I run the following regression using returns without news.

$$R_{it}^{NONEWS} = \alpha + \beta_i R_{3's,t}^{NONEWS} + \varepsilon_{it} \quad (4\text{-}2)$$

with R_{it}^{NONEWS} the returns on asset i (EIC, BOE or SSC) and $R_{3's,t}^{NONEWS}$ the return on 'threes'. The residuals ε_{it} from this regression are an approximation of the returns adjusted for the long term interest rate. Note that these approximated returns are a lower bound of the real interest rate adjusted returns. If the non-fundamental factors influencing the 'threes' and the stocks are correlated, the regression coefficient β_i from equation (4-2) will capture some of these common non-fundamental factors. The residuals from this equation will therefore be smaller than the real interest rate adjusted returns. Table 4.4 reports the volatility of these residual returns together with the actual return volatility.

Table 4.4 Return volatility corrected for the long term interest rate

	EIC		BOE		SSC	
	actual	adjusted	actual	adjusted	actual	adjusted
$V\left(R_{it}^{NONEWS}\right)$	0.0032	0.0027	0.0020	0.0017	0.0020	0.0017
N	331	330	329	328	329	328

Volatility reported for actual returns and returns adjusted for changes in the long term interest rate. All returns are without news.
Source: see figures 3-1a to 3-3b

The table clear shows that volatility in the absence of news is somewhat lower after correcting for the long term interest rate, but differences are small. Only in the case of the EIC the difference is non-negligent. The calculations of the relative importance of news and trading activity on volatility can be redone using these interest rate adjusted returns. In order to do so I make the weak assumption that the volatility generated by interest rate fluctuations was the same during periods with and without news.[8] Subtracting the volatility generated by interest fluctuations from return volatility with news, I construct an estimate of adjusted volatility of returns with news. Together with the estimates of adjusted volatility without news I can estimate the relative importance of news and trading on volatility. Results are unreported, but the key results from this paper stay qualitatively the same: between 57 and 77 percent of return volatility can be ascribed to factors unrelated to the arrival of information from England or changes in the long term interest rate.

[7] When non-fundamental factors behind the three stocks and the threes are correlated, returns on the threes will be spuriously related to returns on the stocks. The correlation between returns on the threes and on the stocks will not just be driven by the interest rate, but by the underlying non-fundamental factors as well.

[8] Returns with news cannot be adjusted for interest rate fluctuations in the same way. Note that the 'threes' carried default risk. During wars their prices tended to fall (Neal 1990). This implies that when news was coming in from England the return on the 'threes' in Amsterdam reflected developments taking place in England. If these developments affected both the 'threes' and the three stocks, the return on 'threes' will not be a good approximation for changes in the long term interest rate.

5 Conclusions

How much of short run asset price volatility is due to news on the fundamental value of a stock and how much can be accounted for by non-fundamental factors related to the trading process like mispricing or investors' liquidity? In this paper I have used a natural experiment provided by the 18th century Amsterdam equity markets to approach this question. In the 18th century a number of British stocks were traded on the Amsterdam exchange and all relevant price information from England reached Amsterdam through the use of mail boats. This paper identifies periods in which these boats could not sail because of the weather and analyzes what this lack of information implied for the volatility of the British stocks traded in Amsterdam. I show that asset price volatility during periods without news was more than a half of the volatility that is observed during periods with news. This suggests an important role for non-fundamental factors in the day to day movement of asset prices

I present a number of empirical tests that support the view that (1) packet boats were the fastest an only channel through which price relevant information reached Amsterdam and (2) that all price relevant information had its origin in London and not in Amsterdam. I also provide a number of robustness tests showing that volatility during the absence of news cannot be accounted for by changes in the short or long term interest rate. I therefore conclude that the short run volatility in the absence of news can really be ascribed to certain factors unrelated to the fundamental value of an asset that have something to do with trading process. What these factors are exactly I leave for future research.

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Appendix A: Identifying the arrival of news

A-1 Benchmark identification

There are two sources available that allow me to infer when news arrived in Amsterdam: the arrival dates of the 'English letters' in Hellevoetsluys and the dates at which the news from these English letters was published in the *Rotterdamsche Courant*. Based on these two pieces of information it is possible to determine quite precisely when news arrived in Amsterdam. To understand how both sources can be used I will first discuss some details of the transportation of letters from London to Amsterdam. Having explained this I will turn to the exact way in which I have used both sources to identify the arrival of news

As mentioned in the main text, the packetboats that brought news from London sailed from Harwich to Hellevoetsluys. In this small harbor near Rotterdam the post bag with English letters was offloaded and from here was sent directly to Alphen aan de Rijn. This town formed the centre of the postal connections in Holland and lied more or less in between Amsterdam and Rotterdam. Only here the post bag was opened and the different packages were sent to the respective towns in Holland, among which Amsterdam and Rotterdam. The reason for this somewhat strange construction was that this ensured that all Dutch towns, especially Rotterdam and Amsterdam would receive the English news at the same time, so that no town could extract any benefits from receiving the news any earlier than the others.[9]

All transport within Holland took place by coach. This way of transport was relatively independent of the weather[10] and the time a coach took to go from one city to another was more or less constant (Knippenberg en de Pater 1988, p. 55)[11]. The information available indicates that it took somewhat less than a day for the letters from Hellevoetsluys to reach Amsterdam. A map from 1810 with the main mail connections in Holland indicates that it took around 10 hours for the mail to travel between Hellevoetsluys and Amsterdam (Knippenberg en de Pater 1988, p. 55).

From the *Rotterdamsche Courant* there is information available on what day a specific packet boat arrived. Unfortunately the paper does not give an exact time of arrival in Hellevoetsluys: it could be during any point of the day[12]. This implies that together with the average time it took for a coach to reach Amsterdam it is only possible to get a approximate indication when the English letters arrived in Amsterdam. Take the example of a boat that arrived on Monday. If the boat had arrived during the night or early in the morning the news would have reached Amsterdam on the same day. If the boat had arrived later during the day, it would have reached Amsterdam only on Tuesday, a day later. Unfortunately this rough indication is not precise enough to determine which share prices reflected news from

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[9] Private correspondence with Jan de Vries. See also Hogesteeger (1989, p. 27) who mentions Waddixveen instead of Alphen a/d Rijn.

[10] The only exception is heavy snowfall. Going through the Amsterdamsche and Rotterdamsche Courant, I found that only very seldom coach services were seriously delayed by the weather.

[11] See also table of transport times of mail to European destinations in Ten Berg (1969, p. 21). While the time for a letter to reach London 'depended on the weather', the time to destinations reached by coach (like Antwerp and Brussels) was constant.

[12] For a number of years it does indicate whether a boat arrived in the morning or afternoon but this indication is still quite rough.

England and which ones did not. Trading in shares occurred during a few hours in the late afternoon (Hoes 1986, p. 5). It is therefore crucial to know whether the English letters arrived before or after these afternoon trading hours.

In order to determine more precisely when the English news arrived in Amsterdam, I use the dates of publication of the English news in the *Rotterdamsche Courant*. This newspaper appeared three times a week (on Tuesday, Thursday and Saturday) and was a morning paper that reported all news that had come in up to the previous day. Based on the editorials from *Rotterdamsche Courant* it seems that the newspaper was sent to the printers early in the evening the day before it came out. The English news reports in the *Rotterdamsche Courant* can first of all be used to determine the of arrival of the news in Rotterdam. Take the example of a boat that arrived in Hellevoetsluys on Monday. If the news it brought in was published in Tuesday's paper, this indicates that the news arrived in Rotterdam on Monday in time to be published in next days paper. If on the other hand the news was published in Thursday's paper, this is an indication that the news must have arrived in Rotterdam Monday evening or on Tuesday.

Because the English letters arrived in Rotterdam more or less at the same time as they arrived in Amsterdam (see the discussion before), it is safe to assume that if news arrived in Rotterdam, it arrived in Amsterdam as well. Taking a closer (unreported) look at the data, I learned that when the English news had arrived early enough to be published in the *Rotterdamsche Courant*, the share prices of the English stocks in Amsterdam that were reported for that day also reflected this news. When, on the other hand, the news arrived too late to be published in newspaper, prices in Amsterdam also did not reflect this news. In short, this implies that the days of publication of the English news in the *Rotterdamsche Courant* allow me to time quite precisely when the English news arrived in Amsterdam. Together with the arrival dates of boats in Hellevoetluys, I can therefore determine which shares prices reflected news from England and which ones did not.

Since the newspapers were only published three times a week this methodology will not always be able to time the arrival of news in Amsterdam precisely. Take for example a packet boat that arrives on Thursday. The news it carries will without any doubt be published in Saturday's newspaper, but it is unclear whether the news reached Amsterdam on Thursday or Friday. This implies that this timing methodology will only work well for boats that arrive on Mondays, Wednesdays or Fridays. Fortunately these are the only days for which a precise timing matters. The *Amsterdamsche Courant*, the source for the share price information, appeared on the same days as the *Rotterdamsche Courant* and the share prices it reported were for Mondays, Wednesdays and Fridays: exactly the days for which the timing methodology works well! For the other days an exact timing does not really matter. To see this take again the example of a boat arriving in Hellevoetsluys on Thursday. In this example it does not matter at all whether the news arrives in Amsterdam on Thursday or Friday: in both cases the news will be reflected in Friday's share prices. Figure A-1 clarifies this.

Figure A-1: Identification the newspapers

Day	Arrival boat	English Column	Arrival Amsterdam	Share prices	Prices with news?
Mon	A		A	X	Yes
Tue		A			
Wed				X	No
Thu	B		B?		
Fri			B?	X	Yes
Sat		B			

Letters indicate linked observations, grey colour indicates which days the newspaper appeared

A-2 Robustness checks

Although I believe that my identification strategy is quite precise, I do perform one robustness check. I redo the identification of the arrival of news in Amsterdam using the arrival dates of the packets boats in Hellevoetsluys only. In other words: I do not use any information provided by the publication of the English news in the *Rotterdamsche Courant*. Instead I assume that news that arrives in Hellevoetsluys on a certain day, can reach Amsterdam the same or next day. Consequently I only use the asset prices of which I can be totally sure that they contain new information or no information at all. This implies throwing away a large part of the data, making the estimates less secure, but I can be totally confident that these estimates will not be biased. Figure A-2 shows this more clearly.

Figure A-2: Identification robustness checks, dropping of observations

Day	Arrival Boat	Arrival Amsterdam	Share prices	Prices with news?
Sun	A	A?		
Mon		A?	X	Yes
Tue				
Wed	B	B?	X	Yes/No (dropped)
Thu		B?		
Fri			X	Yes/No (dropped
Sat				
Sun				
Mon			X	No
Tue	C	C?		
Wed		C?	X	Yes

Letters indicate linked observations, grey colour indicates which days the newspaper appeared

Appendix B: asset prices in 18th century Amsterdam

Of importance for this paper is the exact character of the asset prices reported by the Amsterdamsche Courant. Two important issues are at stake here: are prices spot or on time and do they reflect brokers' quotes or are they actual transaction prices?

B-1 Spot or on time?

The main contributions that use the asset prices from the Amsterdamsche Courant mention that from 1747 onwards prices probably referred to 'prices on time' or forward prices (Van Dillen 1931 and Neal 1987, 1990). This observation is based on the fact that the *Amsterdamsche Courant* reports, together with the price of the share, the month on which a transaction will be settled.

It is not immediately clear how these 18th century prices on time compare to the modern day definition of a forward or future and how these prices should exactly be interpreted. Smith (1919) gives a thorough description of the different type time contracts that were used on the 18th century Amsterdam stock exchange. Together with a number of transaction contracts (see Neal 1987, p. 111, Dickson 1967, p. 335 and several examples in the Amsterdam City Archives N.12 collection) it is possible to figure out how the stock prices reported in the *Amsterdamsche Courant* should be interpreted.

In 18th century Amsterdam a transaction on time involved the following: party S would sell its shares to party B, but the actual transfer of the shares would only take place during the so-called month of 'rescontre' (settlement). In the 18th century this process was entirely standardized and there were four of such rescontre months in a year (during the 1770's February, May, August and November) during which specialized 'rescontreurs' would settle all transactions. So far this closely resembles current day future contracts. The 18th century contracts differed on the timing of the payment B would make to S, in contrast to today this was also deferred to the day of settlement. In addition, all dividend or interest payments made before the day of settlement accrued to B and not to S. Any dividend or interest payments made in this period would be deducted from the price B would have to pay A on the day of settlement.

So even although the shares were still legally held by the seller, the parties acted as if the buyer was already the possessor of the stock. This has important implications for the way investors would have priced time contracts. Essentially an 18th century contract on time resembled the spot purchase of a share with the postponement of the payment to a certain (fixed) point in the future. The relation between a spot price and the price on time can therefore be expressed as:

$$TP_{it} = SP_{it}\left(1+r\right)^{T-t}$$

where TP_{it} is the price on time of asset i at time t, SP_{it} is the spot price, r is the the risk free interest and T is the date of settlement. This expression closely resembles that of modern day futures and implies that different settlement dates coincide with different prices on time.

The most important difference between 18th century contracts on time on modern day futures regards the influence of dividend or interest payments on the price. After the payment of dividend or interest, the price the 18th century time contract would go ex-dividend. It can be shown that this not the case for modern day future contracts. These do not go ex-dividend, unless the date of dividend or interest payment coincides with the day of settlement .

All this implies that there are two testable implications that should hold if this view on 18th century prices on time is correct:

(1) share prices should go ex-dividend
(2) when the date of the 'rescontre' changes from one quote to another (for example from May to August), this should coincide with a rise in the price roughly equal to the three month risk free interest rate (to see this compare equation () for a large and a small T).

Looking at the data both implications are confirmed for the three assets discussed in this paper. All price changes are statistically significant and their size is consistent with the general size of dividends and the level of the three month risk free interest rate.

B-2 Quotes or transaction prices?

A second point of importance is whether the prices reported in the *Amsterdamsche Courant* reflected actual transactions or were quotes from brokers. The information from the literature on this is limited. The only thing we know is that prices were drawn up by a number of sworn brokers (Smith 1919, p. 109 and Jonker 1996). There are a number of reasons to believe that the prices they reported reflected transaction prices. First of all the *Cours d'Estaing,* the main London price current, also reported transaction prices. It is plausible that the *Amsterdamsche Courant* followed the example of its English counterpart. Second of all prices were not always reported. This is consistent with the reporting of transaction prices as these are not available if no trade is taking place (the same thing can be observed in the *Cours d'Estaing*). If prices were brokers' quotes, the *Amsterdamsche Courant* should have also reported prices in the absence of trade. Polak (1924) describes that this happened frequently in the *Prijscourant der Effecten*, the official price current that was set up after the French invasion in 1795 and which reported quotes instead of transaction prices. Thirdly, quotes from brokers were usually given in the form of a bid-ask spread. This can be observed in the *Prijscourant der Effecten* and the letters from brokers which gave quotes for more illiquid assets like foreign government bonds (CAA, N-collection, passim). The *Amsterdamsche Courant* contains no bid-ask spreads and this is another indication that the prices it reports reflect actual transactions. Lastly, some correspondence between brokers and customers on the buying and selling of English stock has survived (Van Nierop 1931). From these letters it appears that, at least in the context of the English stocks, transaction prices were most important. Brokers did not tell their customers at what prices they were willing to buy or sell shares (quotes), but rather they reported at what prices shares were changing hands on the exchange. If these letters are representative for the market as a whole it would be safe to assume that transactions prices were most common, making it unlikely that the *Amsterdamsche Courant* would have reported brokers' quotes.