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for
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No. 96105

THE TOTAL COST OF TRADING BELGIAN SHARES: BRUSSELS VERSUS LONDON

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November 1996

ISSN 0924-7815

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Abstract

Since 1990, London's SEAQ International attracts considerable trading volume in Belgian equities. This paper uses transactions, quotation, and limit order book data to investigate competition between the Brussels CATS market and SEAQ International. It focuses in more detail on the liquidity (indirect costs) measured by the quoted and effective bid-ask spread. CATS outweighs SEAQI for both measures. The effective spread is substantially smaller than the quoted spread. The CATS effective spread shows a U-shape form. This is in line with the different market micro-structure models. Total trading costs on CATS are lower (higher) for small (large) trade sizes.

Keywords: Cost of Trading Shares, Brussels stock exchange, SEAQ International.

JEL Classification: G15

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I. INTRODUCTION

In 1985 the London stock exchange started SEAQ International (the Stock Exchange Automated Quotation (SEAQI)), a screen based dealership market devoted to shares of non-UK companies. London's SEAQI captured considerable trading volume from the continental exchanges in non-UK equities (see e.g. Worthington (1991)). Since 1990, shares of some major Belgian companies are quoted on SEAQI. At the end of 1994, SEAQI denotes about 1204 non-UK companies on its screens of which 14 Belgian ones. Authorities and market participants of the domestic continental exchanges reacted by modernising and adapting their trading systems as brokers wanted to regain the market share lost to London. The Brussels stock exchange also experiences this competitive pressure.

In this paper, we investigate competition between the quote driven SEAQI and the order driven Brussels CATS system (Computer Aided Trading System).[1] We obtained a *simultaneous* record of quotes, limit orders, and transactions in both Brussels and London. This allows us to investigate the cost of trading Belgian shares on CATS on the one hand, and on SEAQI on the other hand. The cost of a trade has at least two components. The first is the commission cost. The second is an implicit cost called the bid-ask spread. The latter arises as it is generally the case that in selling even a modest amount of shares one gets a lower price than one has to pay to buy it.

We provide two different estimates of the bid-ask spread. First, we compute the **quoted** bid-ask spread. That is the difference, for a particular trade size, between the lowest ask price and the highest bid price quoted on a market at a point in time. The quoted bid-ask spread is calculated on the basis of the CATS limit order book for Brussels, and market makers' quotes on SEAQI. In contrast with de Jong et. al. (1995) or Biais et. al. (1995), we observed the *entire* limit order book. More specifically, the data include not only the five best bid and offer prices and quantities but also the other limit orders in the book. In addition, the data include the hidden orders. This allows some interesting comparisons of market liquidity with and without such hidden orders. To sum up, the quoted spread is directly observable in our dataset for both markets. Investors are always able to trade against the quoted prices: the quoted spread is the price one pays for immediacy. Second, we investigate the **effective** bid-ask spread on the basis of transaction prices. That is the average

[1]For an earlier analysis, see Anderson and Tychon (1993a, 1993b).

difference between the price at which a dealer sells at one point in time and the price at which a dealer buys at an earlier point in time. The transactions data for London imply some limitations as the number of transactions in our data set is limited. In addition, there may be some misreporting of transaction times. Further, we investigate the **relation between spread and trade size** on both exchanges.

We find that the quoted spread is substantially larger than the effective spread. The hidden orders account for about 16% of the entire limit order book. By construction, the quoted spread increases with trade size. This increase is sharper for non-cross listed shares than for cross-listed ones. The quoted spread on SEAQI is almost flat in trade size. We find that the effective bid-ask spread on the CATS market shows a U-shape form in trade size. This is in line with the market microstructure models but in contrast with results for the Paris Bourse (De Jong et. al. (1995)). The results for London show that the effective bid-ask spread and trade size are independent. Total trading costs on the CATS market are smaller for small trade sizes.

The paper proceeds as follows. Section II provides a description of the markets in Belgian equities. We discuss the relative importance of both exchanges for trading Belgian shares. Section III analyzes different concepts of liquidity on both exchanges by looking at the quoted and effective spread. Section IV studies total trading costs while section V presents some concluding remarks.

II. DESCRIPTION OF THE MARKETS IN BELGIAN EQUITIES

II.1. Trading volume

The focus of our analysis is the Belgian shares that are denoted on SEAQI. The Belgian section on SEAQI in June 1994 includes 14 shares. As we have no data for the warrant of Petrofina on CATS, we exclude it from our London data set. In order to compare cross listed shares with non-cross listed ones, we selected 25 Belgian shares with the greatest trading volume in 1993 (see Table 1). The evolution of trading volume during 1990-1994 is given in Table 1.[2]

Trade in foreign shares on the Brussels stock exchange accounts for approximately 22%. Note that the 25 Belgian shares account for about 83% of total domestic trading

[2] Trading activity in Belgian shares at other exchanges is negligible.

volume. The cross-listed shares take about 60% of total domestic trading volume. The annual volumes for the Belgian shares on SEAQI are presented in Table 2. We divide the volumes reported by SEAQI by 2 to render them more comparable to Brussels volumes.[3] SEAQI has been successful in attracting trading volume in Belgian stocks. It trades around 110 mia BF per year implying 45% of trading volume on spot and forward in the same shares. SEAQI market share declined in 1994 with 5%. The yearly behavior of the individual shares seems to vary a lot.

Table 1: Annual Volumes Brussels (mioBF)

		1990	1991	1992	1993	1994
Total Brussels		319185	289999	315556	494438	553758
spot %		25.00%	22.29%	16.73%	13.92%	11.16%
forward (CATS)%		75.00%	77.71%	83.27%	86.08%	88.84%
Foreign stocks %		29.28%	24.80%	17.66%	21.64%	22.55%
Domestic stocks %		70.72%	75.20%	82.34%	78.36%	77.45%
Cross-listed firms						
CBR	CBR	5981	6235	6733	16364	19170
Delhaize	DEH	12140	20840	26866	27722	21535
Electrabel	ELB	11794	14809	23495	37575	40291
Fortis/AG	FOR	4774	3015	4164	9998	11612
Generale Bank	GBK	2816	7645	17057	20022	25042
GBL	GBL	4880	3904	3772	8599	10089
GB INNO BM	GIB	6968	8324	11245	16108	13430
Kredietbank	KB	2380	2683	10335	18924	17377
Petrofina	PET	20182	29794	33367	26419	27330
Soc. Generale	SGB	10711	7457	5834	14976	14529
Solvay	SOL	11846	12158	11113	19594	27633
Tractebel	TRC	3271	3670	3757	14965	10908
Union Miniere	UM	4053	3084	3863	9943	30304
(1) Total cross-listed		101795	123616	161601	241210	269252
Other active issues						
Barco	BAR	3628	1879	1996	4791	4505
BBL	BBL	1937	3432	7187	12884	7919
Bekaert	BEK	5693	3745	5400	10343	15167
Comp. Mar. Bel	CMB	1337	6614	3954	5078	6264
Cockerill	COKP	3709	1966	1796	5199	9505
Colruyt	COL	2241	4401	5845	8078	6406
Electrafina	ELC	2537	2479	2783	3600	6062
Gevaert	GEV	2021	1650	1842	3424	4833
Powerfin	PWF	1593	4017	2825	6080	3671
Royale Belge	RB	1873	2139	2955	6962	5423
Tessend. Chemie	TES	2366	1774	2123	3825	6960
UCB	UCB	7390	7510	8428	10064	9070
(2) Total other active		36324	41605	47134	80329	85784
(1)/domestic		45.09%	56.68%	62.19%	62.26%	62.78%
(3)=(1)+(2)		138120	165221	208736	321539	355036
(3)/Domestic		61.18%	75.76%	80.33%	82.99%	82.78%

Source: Brussels stock exchange

[3] Several other studies apply the same procedure as there is some double counting of transactions (Anderson and Tychon (1993a,b), Helbling (1993), Pagano and Röell (1993b)). This double counting may occur as both buyer and seller can report trades to the London stock exchange. Jacquillat and Gresse (1995) show that this could be an overestimation of the importance of SEAQI.

Table 2: Annual volume SEAQI (Belgian Shares)

	1990 mioBF	SEAQI/Br %spot+for	1991 mioBF	SEAQI/Br %spot+for	1992 mioBF	SEAQI/Br %spot+for	1993 mioBF	SEAQI/Br %spot+for	1994 mioBF	SEAQI/Br %spot+for
CBR	552	38.10	1906	30.58	2090	42.17	7892	48.23	6298	32.85
DEH	1649	52.64	7436	35.68	9982	48.84	11311	40.80	12124	56.30
ELB	215	21.03	4960	33.49	10086	51.65	20833	55.44	15520	38.52
FOR	0	0.00	0	0.00	0	0.00	3230	45.51	4813	41.45
GBK	0	0.00	0	0.00	6243	46.46	9240	46.15	12975	51.81
GBL	178	19.00	256	6.56	317	10.13	3182	37.01	5719	56.68
GIB	255	23.26	2479	29.79	3814	45.58	5148	31.96	5223	38.89
KB	762	32.03	2386	88.96	4838	46.81	10671	56.39	8625	49.64
PET	1045	18.27	13962	46.86	13100	39.26	5976	22.62	9008	32.96
SGB	446	21.10	2992	40.12	2425	51.33	9076	60.60	5147	35.43
SOL	253	7.99	2436	20.04	2973	34.99	8659	44.19	11124	40.25
TRC	142	14.54	695	18.93	358	11.69	10600	70.83	2389	21.90
UM	0	0.00	0	0.00	0	0.00	5232	81.44	14443	47.66
TOTAL	5496	25.00	39509	35.96	56224	43.30	111051	47.30	113406	42.12

Source: Brussels stock exchange and SEAQ International

II.2. Trading systems

II.2.1. The trading system on the Brussels CATS market.

The Brussels stock exchange is organized as a continuous market, called the CATS system.[4] The CATS computer system continuously provides information on the market and processes all orders. At 10:00 in the morning, trade starts with a batch auction followed by continuous trading from 10:00 till 16:30. The CATS system is an *order driven* system as traders submit orders before prices are determined (Madhavan (1992)).

Traders can submit two types of orders, limit orders and market orders. A limit order specifies a quantity of shares to be bought or sold at a prespecified price. Priority is given according to price and time of submission. The exact quantity of shares offered or asked at the limit prices, however, is not necessarily known to traders. Extra liquidity is supplied to the market by 'hidden orders': that is portions of limit orders that are there to be executed against but that are invisible to the users of CATS (Röell (1992)). Traders like to hide part of their large orders in this way so as not to alarm market participants. Market orders[5] are executed against the best limit orders outstanding. The exchange uses a discriminatory price rule. In other words, market

[4] Trading on the Brussels stock exchange can be performed on a spot basis (kontantmarkt) or on a forward basis (CATS). The focus of this study is the dominating CATS market.

[5] Traders seeking immediacy can always submit limitorders at a very unfavourable price.

orders are executed at successive prices determined by limit orders on the book ranked by price priority and time of submission.[6] Hence, each inframarginal limit order is executed at its own limit price. A trader submitting a market order runs execution risk for two reasons (Pagano and Röell (1993a)). First, he does not know what price he will receive. Second, he is uncertain about the actual execution of his order. The latter also holds if one submits a limit order. The CATS type of organisation implies a great transparency (Pagano and Röell (1996)). It is a real time system where trades are observed individually. Hence, prices are formed upon observing the history of order flow in Brussels.

II.2.2. The trading system at SEAQ International (SEAQI)

SEAQI is a quotation system operated by the London Stock Exchange. It is a *dealership market* where market makers are obliged to quote 'firm' prices. Quotes are firm if there are more than two market makers.[7] Market makers are obliged to maintain quotes during the mandatory quote period for at least minimum marketable quantities. A market maker displaying a price for a larger size must be prepared to deal at that price and size. Trading in shares on SEAQI takes place by telephone. SEAQI is a *quote driven* market as dealers post prices before order submission (Madhavan (1992)). Traders know at what price they will trade and therefore face no execution risk (Pagano and Röell (1993a)). SEAQI requires no immediate last trade publication. The latter has two consequences. First, dealers satisfy orders without knowing about orders received by other dealers. Second, it enables SEAQI market makers to unwind their positions, or take advantage of the obtained information, either at SEAQI or at the market of 'last resort' for Belgian equities in Brussels. Therefore, it is less transparent than the Brussels CATS market.

Klemperer and Padilla (1993) show that SEAQI has an incentive to offer too much variety from the social point of view. The reason is that if traders have *shopping costs*, they prefer to concentrate their business at a single exchange. Institutional investors, located in London, have established customer relationships with London market makers. If the London stock exchange introduces an extra company on its screens, it captures extra trade in two dimensions. First, it captures business for that product. Second, it steals business from rival stock exchanges for other products. This induces SEAQI to list too many stocks. At the end of 1994, 1204 companies were

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[6] Brokers do not know the identity of the counterparty.

[7] The London stock exchange can allow 'firm' quotation even when there are only two market makers. The mandatory quote period for Belgian stocks is 9:30-15:30 London time.

quoted on SEAQI of which 14 Belgian ones. The Brussels stock exchange only denotes 296 companies. Brussels can only attract foreign institutional investors by offering sufficiently lower transactions costs or higher liquidity (see also Pagano and Röell (1991)).

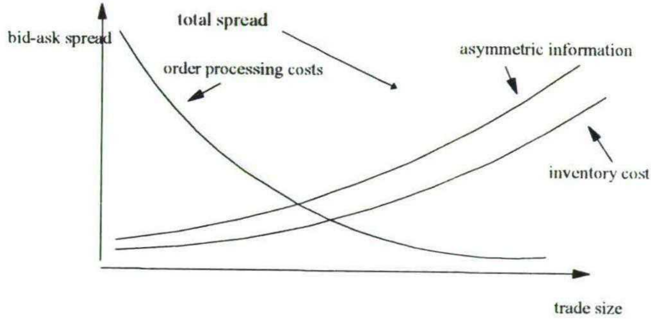
III. LIQUIDITY OF BELGIAN SHARES (INDIRECT COSTS)

In this section, we compare the liquidity offered by the two exchanges. Before investigating the different liquidity measures, we present the theories concerning the bid-ask spread in subsection III.1.. Subsection III.2. describes the data obtained from the Brussels and London stock exchange, respectively. In III.3., we concentrate on the measurement of liquidity. We analyze the size of the bid-ask spread, and its relation with trade size.

III.1. Theories of the bid-ask spread

In the literature, a number of theories are proposed to explain the existence and size of the bid-ask spread. Three complementary theories appear. The first relies on *order processing costs* (Demsetz (1968), Madhavan and Smidt (1991), and Glosten and Harris (1988)). Processing orders implies a cost as being in the market and handling transactions is costly. The bid ask spread is a compensation for the service of dealers. This cost should be declining in trade size as these costs are largely fixed per transaction. A second theory introduces the *cost of inventory management*. A risk averse market maker demands a bid-ask spread as he runs an inventory risk. A dealer with an inappropriate inventory position tries to accommodate that position by reshuffling its bid and ask quotes. Ho and Stoll (1981) show that the inventory management cost is increasing in trade size and price volatility. *Asymmetric information* between a market maker and his traders is a third theory for the existence of a bid-ask spread. The bid-ask spread arises because dealers may trade with unidentified investors who have superior information. Market makers widen the spread to recover from the uninformed traders what they lose to the informed traders. This adverse selection risk should increase in trade size as informed traders are more likely to initiate large trades (Easley and O'Hara (1987)). Figure 1 shows the relation between trade size and bid-ask spread for the three different theories. We expect a U-shape form if the three market microstructure theories are relevant.

Figure 1: Relation between bid-ask spread and trade size



III.2. Data description

We obtained a simultaneous record of quotes, limit orders and transactions in both Brussels and London.

The Brussels data set consists of two parts, namely data on limit orders and transactions data. First, we observed the CATS *limit order* book between June 17 and June 30, 1994.[8] More specifically, the limit order book was downloaded six times per trading day for 25 shares. This implies 1500 limit order books. We know the exact time of downloading. In contrast to previous studies as de Jong et. al. (1995) or Biais et. al. (1995), we observed the *entire* limit order book (see Table 3). More specifically, the data include not only the five best bid and offer prices and quantities broadcasted via the wires, but also the other limit orders in the book. Therefore, we do not have to impute the fifth best limit order price for all sizes beyond the corresponding size. In addition, the data include the hidden orders. As a result, the quoted spread is directly observable. We investigate the importance of the hidden orders in providing liquidity. Besides this limit order book, there is a 'terms' market where brokers can post prices and sizes for at least two million BF. Trades on the 'terms' market have to occur at prices between the best bid and ask prices. The 'terms' market, however, is not used intensively.[9] Second, we have transactions data. During the sample period (June 17-30, 1994), around 20000 transactions

[8]The information was downloaded manually from the CATS screen starting at 10:30, 11:30, 12:30, 13:30, 14:30 and 15:30. Downloading the limit order book of 25 shares took around 30 minutes.

[9] During the sample period, only two transactions were executed on the 'terms' market.

occurred on CATS. As the CATS market is a real time system, the transactions data are time stamped. We also know the broker identification codes allowing us to identify large transactions executed against a series of small transactions.

Table 3: Example of a simplified limit order book (Fortis/AG, 24/06/94, 10h29.52)

total amount	visible amount	buy price	ask price	visible amount	total amount
2800	800	2540	2555	200	
	200	2540	2560	100	
	200	2540	2560	200	
	500	2540	2560	1000	
	300	2535	2560	500	
	200	2530	2560	1000	2500
	500	2525	2570	500	
	500	2520	2575	500	
	200	2515	2580	100	
	200	2515	2580	100	
	100	2510	2585	100	
	200	2510	2590	200	
	500	2510	2590	200	
	100	2505	2595	200	
	200	2505	2595	100	
	200	2505	2600	200	
	200	2505	2600	1000	
	100	2505	2625	400	
	...	...	...	...	

The data from the London stock exchange cover the month June 1994. They consist of two parts. The first is a transcription of all changes in the trading screen for all 13 Belgian stocks. There are 1700 revisions of quotes during the sample period. We know the bid and ask quotes, their input times, their sizes, and the identification codes of the dealers. As market makers are obliged to quote bid and ask prices, we are able to reconstruct the SEAQI screen at every point during the observation period. The second part are the transactions data. During June 1994, 1344 transactions occurred on SEAQI. The data denote the buyer and seller code, the transaction time, the trade price and size, and whether the dealer acts as a principal or an agent. As the SEAQI requires no immediate transaction publication, there may be some misreporting of transaction times. Some deals are reported without transaction time.[10]

Tables 4 and 5 display the deal size statistics in number of shares and value for CATS and SEAQI, respectively.[11] Deal sizes for the individual shares vary a lot on both markets as shown by the large coefficient of variation. The median transaction size on SEAQI is about 8 times larger than on CATS. An average order on SEAQI is around 12 mio BF while in Brussels around 0.9 mio BF. The mean transaction size is about 13 times larger on SEAQI. Obviously, larger deals are more dominantly present on SEAQI.

Table 4: Deal size statistics CATS (17-6-94 30-6-94)

	# shares			value (1000BF)		
	mean	% coefficient of variation	median	mean	% coefficient of variation	median
BAR	197.09	103.91	100	434.17	105.33	220.75
BBL	144.44	247.63	100	587.95	246.88	406.00
BEK	40.27	158.21	20	945.31	156.95	495.00
CBR	151.36	232.94	75	1860.78	231.99	924.38
CMB	217.91	339.42	100	498.66	335.93	231.50
COKP	2757.38	125.01	1000	500.06	125.27	185.00
COL	72.67	106.60	50	536.76	106.83	371.00
DEH	561.93	149.16	400	758.71	148.99	539.20
ELB	190.11	212.33	100	1061.07	212.51	572.50
ELC	242.32	153.76	100	863.32	155.18	362.00
FOR	264.39	122.79	200	679.47	123.08	510.00
GBK	119.48	209.06	100	969.82	208.15	800.00
GBL	161.78	147.60	100	666.65	148.26	413.00
GEV	41.83	99.62	25	378.85	99.57	227.50
GIB	440.32	151.82	300	630.04	152.15	434.40
KB	103.20	152.25	50	670.46	152.21	325.50
PET	79.86	122.22	60	817.88	122.52	610.50
PWF	207.65	274.77	100	597.42	273.05	283.00
RB	104.21	117.91	100	525.84	117.74	494.00
SGB	248.76	207.34	200	542.36	206.02	428.00
SOL	66.49	247.05	50	954.71	247.12	705.00
TES	86.94	191.14	25	849.12	189.74	255.00
TRC	97.90	165.31	50	955.60	165.22	488.00
UCB	25.27	186.22	20	598.12	185.60	469.50
UM	255.25	155.32	150	675.41	155.67	395.25

Source: Brussels Stock Exchange

[10] The transactions data include SEAQI as well as off exchange trades. We are not able to separate those two types of transactions. However, the number of SEAQI trades overwhelms the off exchange trades. Therefore, we believe this is not a serious problem.

[11] Deal size statistics for an auction market are biased downwards: a large order executed against n small orders is reported as n transactions.

Table 5 : Deal size statistics SEAQI (June 1994)

	# shares			value 1000BF			
	mean	% coefficient of variation	median	mean	% coefficient of variation	median	#obs
CBR	1374.26	177.89	400	16909.61	176.29	5049.93	97
DEH	9325.14	253.61	3500	12559.54	250.91	4747.77	168
ELB	2324.75	99.66	1612.5	13088.16	98.90	9092.77	118
FOR	2607.55	317.11	1035	6973.35	324.04	2731.74	60
GBK	1698.75	132.36	890	13966.15	131.34	7284.12	138
GBL	1888.67	208.33	550	8142.18	213.85	2283.95	63
GIB	6495.23	267.63	2050	9866.82	272.05	3196.35	40
KB	944.35	123.71	480	6253.67	124.65	3215.97	93
PET	1328.93	289.08	440	14039.91	285.96	4828.87	157
SGB	1963.50	96.58	1400	4412.05	97.19	3160.38	70
SOL	1018.92	221.62	400	14805.67	214.00	6150.62	131
TRC	1337.36	297.12	314.5	13331.45	294.61	3080.81	56
UM	3875.14	164.91	1599	10317.25	165.47	4297.56	153

Source: London Stock Exchange

III.3. Measuring liquidity

Liquidity is a concept encountered in the financial market microstructure literature. A market is liquid if traders can quickly buy or sell large numbers of shares when they want, and at low transactions costs. Liquidity is measured by the average trading cost, i.e. the difference between the market price at which an order is executed and the 'mid price' (the expected price unconditional on the size and direction of the order) (op. cit. Pagano and Röell (1993b)). A measure of liquidity is the bid-ask spread (gap between the bid and ask quotes). Harris (1990) distinguishes *four* dimensions of liquidity: *width, depth, immediacy and resiliency*. The bid-ask spread for a given number of shares determines the *width*. *Depth* refers to the amount of shares that can be traded at given bid and ask quotes. *Immediacy* refers to the amount of time it takes to carry out a transaction. *Resiliency* is the time it takes before prices revert to former levels after a large order has been received by the market.

We turn to two different measures in III.3.1. and III.3.2. namely the *quoted* bid-ask spread, and the *effective* bid-ask spread. In addition, we investigate their relation with trade size.

III.3.1. Quoted spread on Belgian equities

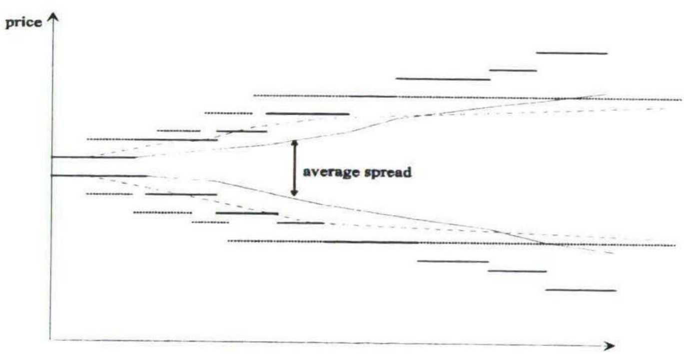
The CATS market is organized as a limit order book. The cost of immediacy is determined by the available orders in the limit order book. The continuous auction is organized as a discriminatory auction.[12] We observed for 25 shares the limit order book in Brussels six times a day during ten trading days. We measure the average quoted spread (ATSPR) for an order size of Q Belgian Francs as follows:

$$ATSPR = \sum_{i=1}^{6}\sum_{j=1}^{10}\left(\frac{2\left(A(ij,Q)-B(ij,Q)\right)}{A(ij,0)+B(ij,0)}\right)\Big/60$$

where A(ij,Q) denotes the ask price of a hypothetical transaction at time ij of size Q, B(ij,Q) the corresponding bid price. A larger trade size results by definition in a larger average quoted spread as the limit order book widens if Q increases. This procedure is applied for the limit order book excluding hidden orders (ATSPR) and including hidden orders (ATSPRH).

The advantage of the Brussels' dataset can be seen from Figure 2. The full short lines show *all* the available orders in the limit order book, i.e. including the hidden orders. This leads to the true average spread represented by the difference between the two

Figure 2: The limit order book and the quoted spread.



[12] The CATS market is organized as a discriminatory auction. Therefore, passive liquidity suppliers submit less agressive limit orders to ensure that they are appropriately compensated in the event of trading with a large trader (Harris (1990)). As a result, the quoted spreads should be larger than under a uniform auction. This analysis is comparable to the discussion of selling treasury bills via a uniform or discriminatory auction (see e.g. Reinhart (1992)).

full lines. The dotted short lines reflect the available data in previous studies (e.g. Biais et. al. (1995) or de Jong et. al.(1995)). In particular, their data only contain the visible limit orders for at the five best prices. In addition, de Jong et. al. (1995) impute the fifth best limit order price for all sizes beyond the range for which the bid and ask price are observed. According to their dataset, the average spread is measured by the difference between the dashed lines. Therefore, their measure of the quoted spread *over*estimates the spread for smaller trade sizes since they do not observe the hidden orders. It *under*estimates the quoted spread for larger trade sizes as the effect of imputing the fifth best price outweighs the hidden order effect.

We apply the same quoted spread measure for the Belgian shares denoted on SEAQI. As we have overlapping data periods, we applied the procedure in two ways. First, we exactly time matched the data in the Brussels limit order book and SEAQI quotes. Second, we computed the different measures for SEAQI at 9:45, 10:45, 11:45, 12:45, 13:45, and 14:45 London time. We present the results for the second procedure as the two estimates did not differ substantially. The quoted spread measure assumes that one executes at the best quote for the amount available and then the residual at the next best and so on. The calculated measure gives a good proxy of immediacy.

Table 6 reports the quoted spread for cross listed shares on both exchanges for various trade sizes. We first discuss the results for the cross-listed shares on CATS. We observe the following. First, the Brussels market is rather *tight* for some shares as the bid-ask spread for the fourchette (lowest ask and highest bid) is low. The quoted bid-ask fourchette varies from 0.22% for Delhaize till 0.52% for GBL. The quoted spread increases immediately with trade size. The latter observation is typical for an auction market. This is because the minimal order size is fairly low : small investors are able to submit limit orders. Second, the market is not very *deep*. This is reflected in a large bid-ask spread for larger trade sizes, or even that the limit order book runs out altogether.[13] Third, note the variability of the quoted spread shares as measured by the t-statistic. Our analysis shows t-statistics around two. This points to a high variability of the spread. These low values, however, are not uncommon. Kleidon and Werner (1993) as well as Petersen and Fialkowski (1994) report t-statistics of comparable size. Pagano and Röell (1993b) obtain higher t-statistics for the Paris Bourse. This can point to a higher execution risk for Belgian shares in Brussels than

[13] We stop reporting the quoted spread whenever at least one limit order book would have been insufficiently deep for a particular trade size. We prefer not to report the percentage of limit order books for which either the bid or ask would have run out since we focus on the observable quoted spread.

French shares in Paris. Fifth, hidden orders increase the depth of the market. Their importance can be seen from the difference between both spread measures. Hidden orders seem to be more important for larger orders. The reasons are the following. Firstly, a fraction of the hidden order is always visible in the book (see also Biais et. al.). Therefore, for small quote sizes, both spread measures are the same. Secondly, hidden orders can be more available at less favourable prices. In other words, they can be less aggressive. We computed the importance of the invisible part of the hidden orders for the 25 Belgian shares. It accounts for about 16% of the entire limit order book. Now we move to the discussion of the SEAQI quoted spreads. We observe the following. First, SEAQI is a dealership market where market makers post prices for minimum marketable quantities. This feature can easily be seen from the table: the quoted spread is independent of size up to a certain amount. Second, the market touch (difference between smallest ask and highest bid price) varies from 0.83 % for Petrofina till 4.09% for Soc Generale (SGB). Second, market tightness in a dealership market is not that big. One reason for this is the size of the mandatory quote volumes. The latter affect dealers' willingness to quote narrow bid and ask prices. Third, the quoted spread shows low standard deviation as can be seen from the rather high t-statistics. This points to low execution risk at SEAQI: investors know the price concession they have to make at SEAQI. Fourth, the market is rather deep and the quoted spread does not increase very much with trade size. We have to keep in mind that dealers are willing to take deals for larger sizes. Finally, we have no information concerning resiliency.

In this section, we compare the different aspects of the quoted spreads for the cross-listed shares in the two different trading systems. First, the market 'fourchette' in Brussels is much smaller than the market 'touch' in London. The quoted spread increases sharply in trade size in Brussels vis-à-vis London. The SEAQI spread remains constant up to the minimum marketable quantities. Second, the results for market depth depend on the individual shares. Some shares show a deeper market in Brussels than in London and vice versa. Third, an investor trading in London faces less execution risk than in Brussels: there is less variation of the bid-ask spread in a dealership market than in an auction market. This confirms the theoretical results of Biais (1993). Fourth, a dealership market seems more robust to large orders. Dealers always quote prices even when large orders enter the market. If a large order hits the limit order book of an auction market, it can take some time before market depth and tightness reach their former level.

Table 6: Average quoted spreads for cross listed shares on CATS and SEAQI.

	CBR			DEH			ELB			FOR		
	CATS		SEAQI	CATS		SEAQI	CATS		SEAQI	CATS		SEAQI
mio BF	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr
0.00	0.36	0.36	1.93	0.22	0.22	1.22	0.25	0.25	0.94	0.51	0.51	2.84
t	1.46	1.46	11.64	2.22	2.22	4.58	2.17	2.17	7.10	1.44	1.44	33.94
1.00	0.39	0.39	1.93	0.28	0.28	1.22	0.30	0.29	0.94	0.62	0.62	2.84
t	1.61	1.61	11.64	2.41	2.35	4.58	2.27	2.17	7.10	1.68	1.68	33.94
2.00	0.43	0.43	1.93	0.34	0.33	1.22	0.33	0.32	0.94	0.76	0.75	2.84
t	1.76	1.75	11.64	2.36	2.24	4.58	2.34	2.19	7.10	1.93	1.92	33.94
3.00	0.46	0.46	1.93	0.41	0.38	1.22	0.36	0.34	0.94	0.90	0.89	2.84
t	1.82	1.79	11.64	2.32	2.16	4.58	2.47	2.23	7.10	2.10	2.06	33.94
4.00	0.50	0.49	2.08	0.47	0.43	1.22	0.40	0.37	0.94	1.03	1.01	2.84
t	1.90	1.82	11.82	2.35	2.14	4.58	2.57	2.23	7.10	2.23	2.16	33.94
5.00	0.54	0.52	2.19	0.54	0.48	1.22	0.43	0.39	0.94	1.18	1.13	2.84
t	1.93	1.81	10.87	2.37	2.15	4.58	2.55	2.22	7.10	2.28	2.23	33.94
6.00	0.58	0.55	2.26	0.60	0.52	1.22	0.46	0.42	0.94	1.32	1.26	2.97
t	2.00	1.83	10.12	2.38	2.16	4.58	2.56	2.23	7.10	2.28	2.23	22.03
7.00	0.62	0.58	2.32	0.65	0.56	1.22	0.50	0.45	0.94	1.48	1.39	3.10
t	2.10	1.86	10.16	2.40	2.19	4.62	2.62	2.27	7.10	2.26	2.20	19.32
8.00	0.66	0.62	2.37	0.71	0.6	1.23	0.53	0.47	0.94	1.63	1.52	3.26
t	2.21	1.93	10.16	2.44	2.21	4.80	2.66	2.30	7.10	2.23	2.16	13.47
9.00	0.72	0.66	2.40	0.77	0.65	1.24	0.56	0.49	0.94	1.80	1.66	-
t	2.32	1.99	10.07	2.47	2.23	4.92	2.72	2.32	7.10	2.16	2.09	-
10.00	0.77	0.71	-	0.83	0.69	1.24	0.60	0.52	0.94	2.00	1.82	-
t	2.37	2.04	-	2.51	2.26	5.01	2.76	2.32	7.10	2.11	2.02	-
12.50	0.95	0.83	-	0.99	0.81	1.25	0.68	0.58	0.94	2.41	2.18	-
t	2.32	2.08	-	2.59	2.26	5.13	2.81	2.30	7.10	2.63	2.13	-
15.00	-	0.95	-	1.17	0.94	1.29	0.77	0.65	0.95	2.93	2.67	-
t	-	2.05	-	2.69	2.28	5.51	2.85	2.29	7.49	2.34	2.16	-

	GBK			GBL			GIB			KB		
	CATS		SEAQI	CATS		SEAQI	CATS		SEAQI	CATS		SEAQI
mio BF	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr
0.00	0.28	0.28	1.16	0.52	0.52	1.77	0.37	0.37	1.32	0.36	0.36	1.50
t	1.83	1.83	9.34	1.68	1.68	5.50	2.18	2.18	11.38	1.84	1.84	17.40
1.00	0.35	0.34	1.16	0.62	0.62	1.77	0.49	0.49	1.32	0.42	0.42	1.50
t	1.81	1.78	9.34	1.73	1.73	5.50	1.98	1.98	11.38	1.99	1.99	17.40
2.00	0.42	0.41	1.16	0.75	0.74	1.77	0.62	0.62	1.32	0.51	0.50	1.50
t	1.74	1.69	9.34	1.69	1.68	5.50	1.88	1.86	11.38	2.19	2.15	17.40
3.00	0.48	0.47	1.16	0.87	0.86	1.78	0.73	0.72	1.32	0.59	0.58	1.50
t	1.69	1.61	9.34	1.72	1.68	7.47	1.91	1.85	11.38	2.37	2.29	17.40
4.00	0.54	0.52	1.16	1.01	0.98	1.79	0.85	0.83	1.32	0.66	0.64	1.50
t	1.71	1.62	9.34	1.75	1.70	9.68	1.75	1.70	12.42	2.45	2.33	17.40
5.00	0.60	0.58	1.16	1.18	1.13	1.79	0.96	0.94	1.33	0.73	0.71	1.50
t	1.78	1.66	9.34	1.74	1.69	11.91	1.68	1.63	14.65	2.45	2.30	17.40
6.00	0.66	0.63	1.16	1.38	1.3	1.79	1.09	1.06	1.33	0.81	0.77	1.50
t	1.86	1.73	9.34	1.69	1.64	14.09	1.60	1.55	16.44	2.46	2.27	17.40
7.00	0.72	0.68	1.16	-	-	1.79	1.24	1.20	1.33	0.88	0.83	1.50
t	1.93	1.78	9.34	-	-	16.25	1.55	1.49	17.29	2.45	2.36	18.31
8.00	0.78	0.73	1.16	-	-	1.80	-	-	1.49	0.97	0.90	1.50
t	1.98	1.80	9.34	-	-	18.35	-	-	7.69	2.46	2.24	20.21
9.00	0.85	0.79	1.23	-	-	1.86	-	-	1.70	1.05	0.97	1.50
t	1.96	1.78	10.33	-	-	17.96	-	-	6.48	2.46	2.24	21.91
10.00	0.93	0.85	1.29	-	-	1.98	-	-	1.88	1.13	1.04	1.50
t	1.82	1.64	10.97	-	-	19.08	-	-	5.75	2.47	2.26	23.42
12.50	-	-	1.42	-	-	2.30	-	-	2.54	1.34	1.21	1.51
t	-	-	11.22	-	-	13.18	-	-	5.55	2.47	2.28	26.52
15.00	-	-	1.51	-	-	-	-	-	-	1.58	1.38	1.61
t	-	-	11.99	-	-	-	-	-	-	2.46	2.33	20.22

% atspr average quoted spread, hidden orders not included, %atspr %atsprh on SEAQI, since no hidden orders.
% atsprh average quoted spread, hidden orders included

	PET			SGB			SOL			TRC		
	CATS		SEAQI	CATS		SEAQI	CATS		SEAQI	CATS		SEAQI
mio BF	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr	% atspr	% atsprh	% atspr
0.00	0.30	0.30	0.83	0.43	0.43	4.09	0.33	0.33	1.87	0.40	0.40	1.94
t	2.90	2.90	5.43	2.19	2.19	7.12	1.92	1.92	6.70	1.79	1.79	6.08
1.00	0.35	0.35	0.83	0.56	0.56	4.09	0.41	0.40	1.87	0.46	0.46	1.94
t	2.79	2.78	5.43	2.64	2.64	7.12	2.18	2.04	6.70	1.80	1.80	6.08
2.00	0.38	0.38	0.83	0.69	0.69	4.09	0.50	0.48	1.87	0.53	0.53	1.94
t	2.76	2.72	5.43	2.74	2.74	7.12	2.11	1.95	6.70	1.78	1.78	6.08
3.00	0.42	0.41	0.83	0.82	0.82	4.09	0.60	0.58	1.87	0.61	0.61	2.11
t	2.67	2.60	5.43	2.92	2.91	7.12	2.08	1.91	6.70	1.79	1.78	8.48
4.00	0.46	0.45	0.83	0.95	0.94	4.09	0.70	0.67	1.87	0.69	0.69	2.32
t	2.70	2.60	5.43	2.95	2.9	7.12	2.07	1.90	6.72	1.77	1.76	12.24
5.00	0.50	0.48	0.83	1.07	1.05	4.09	0.79	0.75	1.88	0.78	0.76	2.46
t	2.77	2.61	5.43	2.93	2.84	7.12	2.02	1.86	6.79	1.74	1.73	14.57
6.00	0.55	0.51	0.84	1.20	1.16	4.12	0.89	0.83	1.88	0.86	0.84	2.76
t	2.85	2.61	6.15	2.89	2.77	7.71	1.99	1.84	6.83	1.72	1.7	20.49
7.00	0.59	0.55	0.86	1.34	1.28	4.16	0.98	0.91	1.88	0.94	0.91	2.97
t	2.92	2.68	7.09	2.88	2.76	9.02	1.97	1.82	6.85	1.72	1.68	19.32
8.00	0.64	0.59	0.87	1.48	1.41	4.19	1.07	0.98	1.92	1.02	0.98	-
t	2.94	2.72	7.95	2.87	2.75	10.29	1.99	1.82	7.09	1.73	1.67	-
9.00	0.68	0.63	0.88	1.63	1.53	4.22	1.16	1.05	1.96	1.10	1.04	-
t	2.97	2.76	8.73	2.81	2.71	11.51	2.03	1.85	7.60	1.76	1.68	-
10.00	0.73	0.66	0.89	1.79	1.66	4.24	1.26	1.13	2.00	1.19	1.12	-
t	3.01	2.80	9.45	2.75	2.67	12.67	2.07	1.89	7.93	1.79	1.68	-
12.50	0.83	0.75	0.92	-	-	4.33	-	1.37	2.07	1.45	1.34	-
t	3.11	2.92	13.27	-	-	17.90	-	1.86	8.25	1.83	1.67	-
15.00	0.93	0.85	0.95	-	-	-	-	1.64	2.12	1.75	1.57	-
t	3.16	3.00	15.23	-	-	-	-	1.71	8.10	1.91	1.72	-

	UM		
	CATS		SEAQI
mio BF	% atspr	% atsprh	% atspr
0.00	0.40	0.40	1.55
t	0.74	0.74	5.13
1.00	0.48	0.48	1.55
t	0.81	0.80	5.13
2.00	0.56	0.54	1.55
t	0.90	0.85	5.13
3.00	0.64	0.60	1.55
t	1.01	0.93	5.13
4.00	0.72	0.66	1.55
t	1.10	1.00	5.13
5.00	0.80	0.72	1.55
t	1.19	1.09	5.13
6.00	0.88	0.78	1.55
t	1.23	1.18	5.13
7.00	0.97	0.84	1.58
t	1.30	1.28	5.39
8.00	1.05	0.90	1.63
t	1.36	1.37	5.99
9.00	1.15	0.97	1.67
t	1.42	1.46	6.38
10.00	1.25	1.04	1.71
t	1.48	1.53	6.63
12.50	1.52	1.22	1.77
t	1.58	1.66	6.84
15.00	1.83	1.44	1.87
t	1.66	1.74	7.04

% atspr= average quoted spread, hidden orders not included, %atspr=%atsprh on SEAQI, since no hidden orders.
% atsprh= average quoted spread, hidden orders included

Table 7: Average quoted spreads for non-cross listed shares on CATS

	BAR		BBL		BEK		CMB		COKP		COL	
mio BF	% atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh
0.00	1.05	1.05	0.66	0.66	0.37	0.37	0.91	0.91	0.68	0.68	0.54	0.54
t	2.45	2.45	1.68	1.68	1.55	1.55	2.36	2.36	2.89	2.89	1.53	1.53
1.00	1.53	1.53	0.86	0.86	0.42	0.42	1.24	1.24	0.80	0.80	0.66	0.65
t	3.35	3.34	2.03	2.01	1.57	1.57	2.74	2.74	2.34	2.34	1.86	1.83
2.00	2.07	2.06	1.06	1.05	0.50	0.50	1.64	1.64	0.95	0.95	0.80	0.80
t	3.21	3.20	2.18	2.16	1.58	1.58	2.62	2.62	2.17	2.17	2.16	2.11
3.00	2.66	2.65	1.22	1.22	0.59	0.58	2.02	2.02	1.13	1.12	0.95	0.94
t	3.38	3.30	2.23	2.21	1.54	1.55	2.62	2.62	2.16	2.10	2.27	2.21
4.00	3.30	3.24	1.43	1.40	0.66	0.64	2.44	2.44	1.34	1.31	1.14	1.13
t	3.73	3.52	2.30	2.23	1.53	1.53	2.67	2.68	2.28	2.15	2.31	2.23
5.00	3.95	3.80	1.65	1.62	0.73	0.70	2.94	2.93	1.56	1.51	1.36	1.34
t	3.94	3.58	2.38	2.29	1.52	1.51	2.68	2.69	2.48	2.27	2.24	2.28
6.00	4.65	4.32	1.90	1.85	0.81	0.76	3.58	3.58	1.79	1.74	1.61	1.59
t	4.06	3.51	2.45	2.34	1.52	1.50	2.59	2.59	2.66	2.41	2.11	2.06
7.00	5.34	4.80	2.15	2.08	0.89	0.82	-	-	2.03	1.96	1.92	1.89
t	4.19	3.43	2.50	2.36	1.50	1.46	-	-	2.78	2.53	1.89	1.85
8.00	5.99	5.23	2.40	2.31	0.98	0.88	-	-	2.27	2.19	2.32	2.29
t	4.26	3.34	2.51	2.36	1.45	1.42	-	-	2.90	2.65	1.63	1.60
9.00	6.58	5.60	2.66	2.55	1.08	0.95	-	-	2.51	2.43	2.82	2.78
t	4.12	3.22	2.51	2.35	1.42	1.38	-	-	3.04	2.79	1.45	1.42
10.00	7.20	5.95	2.92	2.79	1.20	1.02	-	-	2.76	2.67	-	-
t	4.15	3.09	2.49	2.33	1.33	1.31	-	-	3.19	2.93	-	-
12.50	7.70	7.01	-	-	1.60	1.22	-	-	3.41	3.31	-	-
t	5.26	2.83	-	-	1.18	1.21	-	-	3.56	3.29	-	-
15.00	-	-	-	-	-	-	-	-	4.06	3.95	-	-
t	-	-	-	-	-	-	-	-	3.81	3.59	-	-

	ELC		GEV		PWF		RB		TES		UCB	
mio BF	% atspr	% atsprh	%atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh	% atspr	% atsprh
0.00	0.71	0.71	0.48	0.48	1.22	1.22	0.93	0.93	1.22	1.22	0.51	0.51
t	0.97	0.97	1.76	1.76	1.60	1.60	1.80	1.80	1.67	1.67	2.10	2.10
1.00	0.97	0.96	0.60	0.60	1.83	1.83	1.24	1.24	1.45	1.45	0.67	0.67
t	1.11	1.10	1.96	1.96	1.83	1.83	2.29	2.29	2.15	2.15	2.28	2.24
2.00	1.24	1.23	0.77	0.77	2.58	2.58	1.54	1.52	1.69	1.69	0.85	0.85
t	1.18	1.16	1.99	1.99	2.01	2.01	2.37	2.36	2.53	2.53	2.34	2.26
3.00	1.51	1.49	0.97	0.96	-	-	1.85	1.79	1.98	1.98	1.01	1.00
t	1.22	1.20	2.11	2.06	-	-	2.25	2.22	2.68	2.68	2.35	2.26
4.00	1.95	1.91	1.20	1.18	-	-	2.19	2.08	2.32	2.32	1.17	1.15
t	1.07	1.04	2.31	2.21	-	-	2.13	2.07	2.57	2.57	2.34	2.24
5.00	-	-	1.45	1.42	-	-	-	-	2.52	2.52	1.33	1.30
t	-	-	2.37	2.24	-	-	-	-	2.52	2.51	2.36	2.21
6.00	-	-	1.71	1.67	-	-	-	-	3.25	3.25	1.53	1.47
t	-	-	2.38	2.22	-	-	-	-	2.22	2.22	2.38	2.15
7.00	-	-	1.98	1.93	-	-	-	-	-	-	1.78	1.68
t	-	-	2.45	2.24	-	-	-	-	-	-	2.25	1.99
8.00	-	-	2.29	2.20	-	-	-	-	-	-	2.06	1.92
t	-	-	2.58	2.32	-	-	-	-	-	-	2.21	1.93
9.00	-	-	2.61	2.51	-	-	-	-	-	-	2.41	2.22
t	-	-	2.74	2.42	-	-	-	-	-	-	2.25	1.93
10.00	-	-	2.96	2.84	-	-	-	-	-	-	2.82	2.57
t	-	-	2.88	2.52	-	-	-	-	-	-	2.31	1.94
12.50	-	-	4.04	3.87	-	-	-	-	-	-	-	-
t	-	-	3.14	2.69	-	-	-	-	-	-	-	-
15.00	-	-	-	-	-	-	-	-	-	-	-	-
t	-	-	-	-	-	-	-	-	-	-	-	-

% atspr – average quoted spread, hidden orders not included

% atsprh – average quoted spread, hidden orders included

Table 7 reports the results for the non-cross listed shares. These shares are less frequently traded than the cross-listed ones. This is reflected in the liquidity of their markets. First, the market is not that tight as can be seen from the higher quoted spreads at the fourchette. Second, the limit order book runs out very fast. In addition, the quoted spread increases quickly with trade size. In other words, the limit order book for the non-cross listed shares is not deep. Third, traders willing to trade larger sizes against the limit order book have to split up their orders into smaller ones. This splitting up device is less present for the cross-listed shares.

III.3.2. Effective spread and trade size

The quoted spread is the cost one incurs for immediate execution. Other trading strategies can offer lower trading costs. For instance, in a *dealership* market, market makers often grant discounts to medium and large retail orders. Therefore, transaction prices differ from dealers' posted quotes. In an *auction* market, timing of the order submission can substantially decrease the indirect trading costs. This is the focus of this subsection. The proposed proxy of the bid-ask spread is the effective bid-ask spread. This measure is based on transactions prices. More specifically, we propose the absolute difference between the, at the same time, quoted mid-price (A(i,0)+B(i,0))/2 and transaction price T(i,Q). The spread is twice this difference as it is the price difference between a buy and sell order. Formally,

$$S_E(Q) = 2\sum_{i=1}^{N}\left|\frac{2T(i,Q)}{A(i,0)+B(i,0)} - 1\right| / N$$

This measure requires for the same time stamps knowledge of transaction price and the limit order book (CATS), or the quote data (SEAQI).

<u>a) SEAQI</u>

We start with analyzing SEAQI as that data set contains transaction prices as well as quote data. As in De Jong, Nijman and Röell (1995), we exclude all transactions outside the mandatory quote period. The mid-quote outside those hours is not a reliable proxy for the market valuation of a stock. Before discussing the results, three remarks are at order. First, the number of transactions in our data set (June 1994) is limited. Second, some trades did not include dealing times. Therefore, we dropped these observations. Third, there may be some misreporting of trading times. Given these caveats, we discuss the results of Table 8.

Table 8: Effective spread $s_{EI}(Q)$(%)on SEAQI

	all sizes				size<3mio		3<size<9		size>9mio	
	mean	std	median	nobs	mean	nobs	mean	nobs	mean	nobs
CBR	0.9275	0.7622	0.7383	40	1.1316	9	0.5311	13	1.1117	18
DEH	0.95	1.2204	0.4973	78	0.6204	29	0.9007	23	1.3612	26
ELB	0.9041	0.8551	0.7035	59	0.8338	12	1.0558	12	0.8762	35
FOR	1.1907	0.7317	1.2228	23	1.0794	14	1.6617	6	0.7683	3
GBK	0.6395	0.5206	0.5749	68	0.6083	18	0.8231	24	0.4916	26
GBL	0.7537	0.6433	0.5879	27	0.842	13	0.9706	5	0.5057	9
GIB	0.9919	0.8965	0.6347	18	1.0118	9	0.7329	7	1.8086	2
KB	0.8867	0.9121	0.6202	45	0.8831	21	1.0287	12	0.7511	12
PET	0.9135	1.3723	0.5809	71	1.2758	31	0.5398	11	0.668	29
SGB	1.8255	1.4687	1.2659	27	1.7576	11	1.6812	12	2.4452	4
SOL	1.1577	1.1295	0.8111	61	0.9955	26	1.4072	12	1.211	23
TRC	1.1236	0.5537	1.0167	21	1.0459	10	1.0288	5	1.3321	6
UM	1.0044	0.7929	0.7407	81	0.9792	32	0.9669	20	1.0582	29

The effective spread is lowest for the Generale Bank (0.64%) and highest for the Societe Generale (1.83%). There is a lot of variation in the effective spread as can be seen from the standard deviation. The effective spread is substantially smaller than the quoted spread. This implies that a lot of trades are executed within the market touch.

Table 9: Model based estimates of effective spread (SEAQI) .

Panel A	$S_{EI}(Q)/2 = \delta + \beta Q_t + \alpha z_t + \gamma / z_t$				
	β	α	γ	Wald	# obs
chr	0.2759	0.0060	0.2070	31.027**	40
t	3.6672	4.0334	4.7115		
deh	0.2476	0.0155	0.0228	8.222**	78
t	2.7529	1.7524	2.8398		
elb	0.4952	-0.0024	-0.0080	0.445	59
t	5.7656	-0.6404	-0.4461		
for	0.6844	-0.0096	-0.0497	5.646*	23
t	5.5052	-0.7010	-1.3636		
gbk	0.3546	-0.0033	-0.0199	3.044	68
t	6.7918	-1.7254	-0.5755		
gbl	1.0753	-0.0196	0.0232	4.982*	27
t	6.9859	-1.7777	0.2633		
gib	0.4513	0.0284	-0.1297	19.928**	18
t	1.4127	1.1552	-0.6000		
kb	0.3057	0.0071	0.0107	6.930**	45
t	3.8266	0.6779	2.4987		
pet	0.2718	0.0013	0.0805	1.583	71
t	4.4764	0.5690	1.2541		
sgb	0.6764	0.0386	0.1555	2.079	27
t	2.3362	0.8848	1.4401		
sol	0.5331	0.0064	-0.0515	2.482	61
t	4.2374	0.8489	-0.9162		
trc	0.4800	0.0208	-0.0508	12.952**	21
t	5.2168	2.3050	-1.4101		
um	0.4106	0.0054	0.0001	1.883	81
t	6.9921	1.3309	0.0051		

Panel B: Implied % effective spread (SEAQI)						
mio BF	0.50	1	3	5	10	15
chr	1.3856	0.9776	0.7256	0.6942	0.7125	0.7583
deh	0.6017	0.5718	0.6036	0.6597	0.8105	0.9644
elb	0.9560	0.9696	0.9705	0.9629	0.9401	0.9163
for	1.1605	1.2502	1.2780	1.2528	1.1665	1.0737
gbk	0.6264	0.6628	0.6760	0.6681	0.6390	0.6072
gbl	2.2238	2.1579	2.0486	1.9641	1.7636	1.5661
gib	0.4122	0.6999	0.9863	1.1344	1.4439	1.7362
kb	0.6614	0.6470	0.6611	0.6866	0.7555	0.8258
pet	0.8668	0.7072	0.6052	0.5891	0.5864	0.5943
sgb	2.0136	1.7412	1.6883	1.8013	2.1564	2.5323
sol	0.8665	0.9759	1.0704	1.1098	1.1845	1.2522
trc	0.7779	0.9002	1.0511	1.1479	1.3662	1.5777
um	0.8268	0.8322	0.8537	0.8754	0.9295	0.9837

Heteroskedasticity and autocorrelation consistent t-statistics below parameter estimates
Wald is a $\chi 2$ (2) test of joint significance of α and γ
*(**)significant at 10(5)% significance level

Table 8 also reports the effective spread for several size classes. We computed the effective spread for three groups of trade size: smaller than 3 million BF, between 3 and 9 million BF, and the rest. The effective spread is in general not higher for a higher trade size. In order to estimate the relation between effective spread and trade size, we regress the following equation:

$$S_{Et}(Q)/2 = \delta + \beta Q_t + \alpha z_t + \gamma / z_t$$

with $S_{Et}(Q)$ = effective spread for transaction at time t (not in absolute values)
Q_t=1(-1) if transaction price at time t > (<) mid-quote for transaction at time t
z_t = size of transaction in mio BF at time t (+ for buy order, - for sell order).

This equation is a flexible functional form allowing for different shapes. We censored the large trade sizes to reduce the impact of very large transactions. As de Jong et. al., we took the 95% quantile. The results are shown in Table 9, panel A. The parameter estimates can be interpreted as percentage price effects. Twice the coefficient β is the estimated effective spread for trade size zero. The effects of trade size vary across shares. Their is little evidence that there is a trade size effect. The Wald test for trade size is significant at 5% in 5 cases out of 13. The results, however, suggest different shapes. This can be seen in Panel B of Table 9 where we present the implied estimates. These results are comparable to those of De Jong, Nijman and Röell (1995) who do not find a significant trade size effect for French equities denoted on SEAQI.

b) CATS

We can not apply the same procedure for estimating the effective spread on CATS as we have no *continuous* record of the limit order book. Therefore, we have to infer the spread by other means. A first proxy is Roll's measure. Even if the market is informational efficient, and no news arrives, observed market price changes are not independent because recorded transactions occur either at the bid or at the ask, not at the average (Roll (1984)). Roll's measure assumes that the next order arriving in the market is with equal probability a sell or buy order. A buy order will be executed at the ask price while a sell order at the bid price. The spread estimators based on transaction prices use the first order autocovariance of the returns. The measure of the implicit bid-ask spread proposed by Roll (1984) is :

$$S_{roll} = 2\sqrt{-\text{cov}(r_t, r_{t-1})}$$

where r_t is the percentage return on the stock between time t-1 and time t.

We applied Roll's estimator to transactions data for 25 Belgian shares over the period June, 17 1994 to June, 30 1994.[14] There is no problem of timing the transaction as the orders are transmitted through the computerised CATS system. As the auction market uses a discriminatory price rule, big orders are executed against more than one limit order at different prices. These orders are easily identified as they show the same time stamp and buyer or seller code. As in De Jong, Nijman and Röell (1995) we take these cases as *one* transaction with the quantity weighted average as price. The results are shown in column 2 of Panel A of Tables 10 and 11. The estimates of S_{roll} differ a lot across companies. It is smallest for Delhaize and highest for Powerfin. The Roll model has been extended to incorporate other aspects of the bid-ask spread.

Table 10: Model based estimates of effective spread (CATS)

Panel A: $\Delta p_t \; b_0 + (S/2)Q_t + \alpha z_t + \gamma / z_t$ + lagged terms + $e_t + \Delta u_t$

	S_{roll}	S/2	α	γ	Wald	# obs
cbr	0.2489	0.1221	0.0105	0.0317	16.948**	504
t		7.5552	3.2172	3.7995		
deh	0.1531	0.0967	0.0079	0.0052	12.606**	846
t		14.4725	2.5421	3.3594		
elb	0.2418	0.1144	0.0082	0.0063	15.341**	959
t		13.8793	3.3350	3.4552		
for	0.4134	0.1996	0.0071	0.0246	5.646*	597
t		6.4927	0.8312	2.2678		
gbk	0.2216	0.1193	0.0061	0.0065	5.502*	730
t		11.7258	1.4578	2.2678		
gbl	0.3926	0.1335	0.0236	0.0301	9.495**	520
t		3.4596	1.9326	3.0501		
gib	0.2305	0.1567	0.0136	0.0071	4.617*	643
t		9.7984	1.7235	1.8376		
kb	0.2637	0.1349	0.0156	0.0080	5.602*	605
t		7.3314	2.3402	1.7155		
pet	0.2891	0.1371	0.0115	0.0024	10.185**	946
t		11.3089	2.1921	0.5722		
sgb	0.3918	0.2128	0.0252	0.0070	2.044	632
t		6.4507	1.4126	0.8766		
sol	0.2155	0.1391	0.0089	0.0095	11.501**	721
t		11.8802	2.6229	2.8986		
trc	0.3602	0.0989	0.0293	0.0293	15.565*	625
t		4.1985	3.9003	2.6371		
um	0.2283	0.1227	0.0140	0.0111	15.971**	744
t		10.1635	2.4731	3.9964		

Panel B: Implied % effective spread cross-listed shares

mio BF	0.25	0.50	1	3	5
cbr	0.5031	0.3815	0.3286	0.3283	0.3619
deh	0.2390	0.2221	0.2196	0.2443	0.2745
elb	0.2833	0.2622	0.2578	0.2822	0.3133
for	0.5996	0.5047	0.4626	0.4582	0.4800
gbk	0.2937	0.2707	0.2638	0.2795	0.3022
gbl	0.5196	0.4110	0.3744	0.4287	0.5150
gib	0.3770	0.3554	0.3548	0.3997	0.4522
kb	0.3416	0.3174	0.3170	0.3687	0.4290
pet	0.2992	0.2953	0.3020	0.3448	0.3902
sgb	0.4942	0.4788	0.4900	0.5815	0.6804
sol	0.3587	0.3251	0.3150	0.3379	0.3710
trc	0.4469	0.3443	0.3150	0.3931	0.5025
um	0.3412	0.3038	0.2956	0.3368	0.3898

Heteroskedasticity and autocorrelation consistent t-statistics below parameter estimates
Wald is a $\chi 2$ (2) test of joint significance of α and γ
*(**)significant at 10(5)% significance level

[14] We delete overnight returns as these are unlikely to follow the same return process as intraday returns.

Table 11: Model based estimates of the effective spread for non-cross listed shares (CATS)

Panel A: $\Delta p_t = h_0 + (S/2)Q_t + \alpha z_t + \gamma / z_t + \text{lagged terms} + e_t + \Delta u_t$

	S_{roll}	(S/2)	α	γ	Wald	# obs
bar	0.6498	0.6763	-0.1344	-0.0575	3.695	136
t		4.5668	-1.8590	-1.8005		
hbl	0.5940	0.2101	0.0314	0.0257	7.496**	479
t		5.1912	2.4936	1.9511		
bek	0.3102	0.1364	0.0097	0.0132	5.128*	815
t		7.5061	1.5862	2.2329		
cmb	0.6937	0.2761	0.0085	0.0309	4.706*	429
t		4.5019	0.6495	2.0260		
cokp	0.5055	0.3736	0.0177	0.0004	0.494	184
t		3.4000	0.3460	0.0203		
col	0.3931	0.2081	0.0136	0.0037	0.786	463
t		5.9883	0.8837	0.3691		
elc	0.2772	0.1620	0.0140	0.0166	7.395**	333
t		5.9235	1.6480	2.7195		
gev	0.3300	0.1855	0.0882	-0.0003	9.337**	426
t		2.2130	1.7950	-0.0148		
pwf	1.1071	0.7256	0.0092	-0.0228	1.877	129
t		5.8630	0.3780	-1.0199		
rb	0.4710	0.2051	0.1447	0.0361	16.376**	503
t		4.0957	3.3581	3.6488		
tes	0.9494	0.2931	0.0252	0.0660	1.321	78
t		2.1359	0.7045	0.8782		
ucb	0.3955	0.1762	0.0154	0.0157	2.998	507
t		5.3090	1.4803	1.5010		

Panel B: Implied % effective spread non-cross listed shares

mio BF	0.25	0.5	1	3	5
bar	0.8257	0.9883	0.9688	0.5079	
hbl	0.6415	0.5543	0.5343	0.6256	0.7443
bek	0.3829	0.3351	0.3185	0.3396	0.3747
cmb	0.8039	0.6845	0.6312	0.6240	0.6498
cokp	0.7596	0.7667	0.7835	0.8539	0.9247
col	0.4528	0.4447	0.4508	0.5000	0.5533
elc	0.4636	0.4044	0.3852	0.4193	0.4710
gev	0.4130	0.4582	0.5469	0.9002	1.2532
pwf	1.2734	1.3691	1.4239	1.4909	1.5336
rb	0.7717	0.6995	0.7719	1.3023	1.8713
tes	1.1265	0.8752	0.7685	0.7812	0.8642
ucb	0.4857	0.4306	0.4146	0.4554	0.5129

Heteroskedasticity and autocorrelation consistent t-statistics below parameter estimates
Wald is a $\chi 2$ (2) test of joint significance of α and γ
*(**)significant at 10(5)% significance level

A second indirect measure of the effective spread is based on a structural model of transaction prices. These estimators do not need the limit order book to obtain a proxy for the effective spread. However, they require information whether the transaction was buyer or seller initiated. That information, however, is partly missing in our dataset. We can classify the market and limit orders that are executed against more than one limit order. These account for about 17% of all orders. For the remaining orders, we apply the zero-uptick/zero-downtick method to classify if a transaction was buyer or seller initiated. More specifically, if the price increases (decreases), we assume the trade was buyer (seller) initiated. If the price remains constant, we assume the same initiation as the previous trade.[15] This allows us to estimate the following relationship (for derivation and econometric issues: see the appendix)

$$\Delta p_t = h_0 + \left(S/2\right)Q_t + \alpha z_t + \gamma / z_t + \textit{lagged terms} + e_t + \Delta u_t$$

[15] Biais, Hillion, and Spatt (1993) applied this rule to transactions data from the Paris Bourse. Their results show that the rule classifies 93 % of the orders correctly. Our results for the 17% of the orders we could classify are similar. In addition, there is a self correcting mechanism as the orders we could classify are spread all over the data. Therefore, we believe that more than 95% of the orders is classified correctly.

The price change is a function of whether the trade was buyer or seller initiated (Q_t=1 (-1) if the transaction was buyer (seller) initiated), and of the size of the trade (z_t). We censored the large trade sizes to reduce the impact of very large transactions. We took the 99.5% quantile.[16] The estimation results for the cross-listed shares are shown in Panel A of Tables 10. We focus on the trade size effect. The coefficients of size and inverted size are small. However, according to the Wald test, 12 out of 13 are jointly significant at the 10% level. In addition, they all show a U-shaped form. This can be seen from the implied estimates in Panel B of Table 10. This is in line with the different market microstructure theories but in contrast to the findings of De Jong et. al. (1995) for the Paris Bourse. Table 11 shows the results for the non-cross listed shares. Trade size seems to be less important as shown by the results of the Wald test. Most shares, however, show also a U-shaped form. The implied estimated effective spreads are higher for non-cross listed shares than for cross-listed ones.

c) Comparing CATS and SEAQI

Comparing indirect trading costs by means of the effective spread shows that Brussels dominates London. This result is comparable to the one obtained in comparing London and Paris (De Jong, Nijman and Röell (1995)). First, the difference between Brussels and London decreases as trade size increases. The difference remains at least 0.2% (KB trade size 10mio). Second, there is considerable variation across shares. Therefore, we cannot uniformly conclude for which trade size London dominates Brussels in terms of indirect trading costs. Third, London and Brussels show a smaller difference in effective spread than in quoted spread.

IV. TOTAL TRADING COSTS

Traders submitting orders incur at least two costs namely a direct and indirect trading cost. The former is measured by the commission rate. The latter is the impact on the price of submitting an order and was the focus of section III.3.. In this section, we add both cost components to obtain a picture of the competitiveness of the Brussels CATS and the London SEAQI market. Until October 21, 1994, commission rates on

[16] Hausman et.al and de Jong et. al. also censor at the 99.5% quantile.

the Brussels stock exchange were fixed according to a decreasing schedule (see Table 12). The London Stock exchange publishes yearly an overview of commission rates charged on SEAQI (see Table 12). Comparison of both schedules shows that commission rates on CATS are substantially higher than on SEAQI.

Table 12: Commission rates.

Brussels (CATS) before 21/10/94		%
Transaction tax		nil*
Commission 200BF plus		
	0-5mio BF	0.8
	5-10mioBF	0.6
	10-20mioBF	0.3
	20-30mioBF	0.2
	>30mioBF	negotiable
Additional charge		0.03
Brussels (CATS) after 21/10/94		%
Transaction tax		nil*
Commission		negotiable
Additional charge		0.03
London SEAQI		%
Transaction tax		nil
Commission (1994) for Deal Size £		
	0-600	3.70
	601-2000	1.33
	2001-10000	0.61
	10001-20000	0.36
	20001-50000	0.22
	50001-100000	0.17
	100001-250000	0.16
	250001-1000000	0.14
	>1000000	0.15

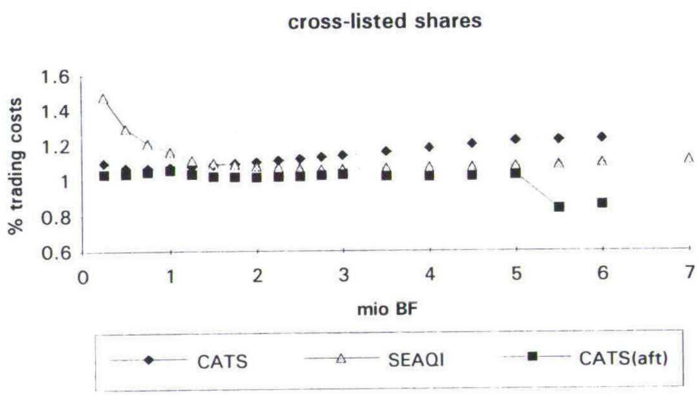
* 0.17 for non-institutional domestic investors

Source: Brussels stock exchange, and London Stock exchange quarterly

Adding both cost components yields total trading costs for our sample period (June 1994). We apply the *quoted spread* as a measure for indirect trading costs. Applying the same exercise with the effective spread would not yield additional insights. We take as indirect trading costs the unweighted average for all shares. We offer total trading cost measures for CATS up to 6 mio BF and SEAQI up to 7 mio BF as this is the deepest size available for all shares. CATS outweighs SEAQI for deal sizes up to about 1.5 mio BF. SEAQI provides lower trading costs for larger trades. The CATS percentage trading costs increase with deal size as the quoted spread increases more than the commission schedule decreases. For Brussels, commissions dominate total transactions costs. The reverse holds for SEAQI.

Since October 21, 1994, commission rates on the Brussels stock exchange have been liberalized. Until now, the liberalisation of commission rates did not induce a price war between brokers. However, some brokers and banks decreased their commission rates for large orders.[17] In order to gain insights in the effects of the liberalisation of commission rates, we present the following exercise. The hypothesis often advanced is that high commission costs lead to low execution costs and vice versa. Berkowitz et. al (1988) estimated the trade off between direct and indirect transactions costs at the NYSE between different types of brokers. Their results indicate that there is not a one to one trade off between both types of costs. More specifically, their results show that a decrease of 10 basis points in commission rates implies an increase of indirect trading costs of about 2 basis points. In addition, lowering commission rates in Brussels has effects on the strategies of SEAQI dealers. The latter can improve their quotes. In other words, the indirect trading costs on SEAQI may decrease. In figure 3, we also applied the commission schedule of a large representative bank after the liberalisation of commission rates. Figure 3 shows the results incorporating the results of Berkowitz et. al. on the impact on indirect trading costs (CATS(aft)).

Figure 3: Trading cost on the basis of the quoted spreads.



Given the caveats mentioned earlier, trading costs seem fairly comparable between SEAQI and CATS after the liberalisation of the commission rates in Brussels. Therefore, we can conclude that this liberalisation enables brokers to compete with SEAQI dealers for larger deals.

[17]The 'Financieel Ekonomische Tijd' of 10/12/94 provides a short survey of commission schedules. Their conclusion is that the previously fixed commission rates remain for smaller transactions. Commission rates for larger transactions, however, decreased.

V. CONCLUDING REMARKS

Since 1985, London's SEAQ International has been successful in capturing trading volume in non-UK equities from the continental exchanges. This paper investigates competition for trading Belgian shares between SEAQ International and the Brussels CATS market. More specifically, we compared direct and indirect trading costs for Belgian shares on both exchanges. We used a simultaneous record of quotes, limit orders, and transactions in both Brussels and London. Our dataset of Brussels encompasses all limit orders. More precisely, it incorporates not only the five best bid and ask prices and quantities but also the other limit orders in the book. In addition, the data include the hidden orders. As a result, our dataset allows to obtain unbiased estimates of the quoted bid-ask spread reflecting the cost of immediacy. The results indicated that the Brussels CATS market is considerably tighter than SEAQ International. The latter, however, is deeper. The results about the size of the effective spread go in the same direction. The advantage of Brussels, however, is smaller.

We investigated the relation between bid-ask spread and trade size. The quoted spread is, by construction, increasing in trade size. This feature is more important for non-cross listed shares. The results for the relation between effective spread and trade size depend on the exchange. Trade size seems to be important on the CATS market. The results indicate a U-shape form implying a larger market impact for small and large trade sizes whereas a smaller one for intermediate trade sizes. This is in line with the different market microstructure theories. Their is little evidence that there is a trade size effect on SEAQ International for Belgian equities.

Total trading costs indicate that Brussels is cheaper for small transactions while SEAQ International dominates for larger ones. This explains to some extent the location of financial activity. More precisely, larger transactions typically occur on SEAQ International whereas smaller ones on the Brussels CATS market.

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APPENDIX

Model based estimates of the effective bid-ask spread.

We make some assumptions concerning the price generating process.

The price p_t is equal to the unobserved mid-price y_t, plus or minus one half times the spread for the fourchette, the effect of trade size and inverse trade size (z_t), plus an error term u_t. Formally,

$$p_t = y_t + (S/2)Q_t + \alpha z_t + \gamma/z_t + u_t \qquad (A1)$$

with Q_t = 1 (-1) if transaction was buyer (seller) initiated.

z_t = size of trade (buy = positive sign, sell = negative sign)

y_t = unobserved mid-price.

In order to have observables only, we have to make assumptions concerning the mid-price y_t.

If there is asymmetric information and inventory control by market makers, they will revise the mid-price and quotes after a trade occurs. Suppose $(1-\pi)$ is the fraction of the spread corresponding with asymmetric information and inventory control, and π the fraction corresponding with processing cost. The mid price after a transaction then looks like follows:

$$m_t = y_t + (1-\pi)((S/2)Q_t) \qquad (A2)$$

The public information arriving between two trades influences the new mid price

$$y_t = \beta_0 + m_{t-1} + e_t \qquad (A3)$$

with β_0 the average and e_t the unexpected public information.

After taking first differences of (A1), and substituting A2 and A3 into A1, we obtain the following equation:

$$\Delta p_t = \beta_0 + \left(\frac{S}{2}\right)Q_t + \alpha z_t + \frac{\gamma}{z_t} + lagged\ terms + e_t + \Delta u_t$$

This equation can be estimated by OLS if p_t and Q_t are observable, and Q_t and z_t are uncorrelated with the error terms. The trade sign Q_t and the error term might be correlated implying that an instrumental variable technique should be used. The error terms follow a first order moving average structure and probably are heteroskedastic. All this implies that the standard errors have to be corrected. We apply the method of Newey and West (1987) to compute heteroskedasticity and autocorrelation consistent standard errors.

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