LIMIT ORDER BOOK RECONSTRUCTION AND BEYOND: AN APPLICATION TO ISTANBUL STOCK EXCHANGE

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Abstract

We discuss the use of order book as a source of information and show step by step the procedure of its reconstruction for the case of Istanbul Stock Exchange. We then propose many new variables derived from the order book potentially prolific for future research. We also put forward an original approach by incorporating trades into the order book.

Key words: order, transaction, order book, trading, microstructure, financial markets, Istanbul Stock Exchange

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I. Introduction

Limit order book dynamics constitute a major concern of recent studies on financial markets. These studies are more and more popular as markets become computerized and centralized. Book analysis is key to understand the functioning of such purely order-driven exchanges as Euronext, Hong Kong, Toronto or Australian Stock Exchanges. In these venues, information companies such as Reuters or Bloomberg usually diffuse five best prices separately at bid and ask sides with the number of waiting orders and depths (sum of shares) at each price level and several statistics like open, close, percentage variation, volume-weighted average price, up and down limits and so forth. Furthermore, just near the order book, transaction book gives the prices, volumes and time stamps of the five last trades with their signs[1] (See Appendix A.1., right window). Besides, depending on the exchange's transparency policy or the profile of the investor (whether retail or institutional), it is even possible to screen separately each order in the book (See Appendix A.1., left window), the quotes for ten best prices instead of five (See Appendix A.2., left window) or the names of brokers who bought or sold (See Appendix A.2., right window).

Order and transaction books contain non-negligible information about short-term price formation process because the state of the book shows the actual demand for and supply of the stock. Hence, traders closely follow these books. However, although information companies keep past transaction records for more than a year, order data are not available. Then, academic researchers usually have to reconstruct the order book with the crude order and trade data they receive from the stock exchanges.

[1] '+', '-' or '=' signs in Fininfo and '↑' and '↓' signs with different colors in Reuters are used to show the direction of the trade.

Even though some stock exchanges supply past order book data[2] or information companies have tools which make it possible to transfer and stock the data to spreadsheet programs, preparing the full order book has some advantages over the datasets obtained in these ways. First of all, we are not limited to five best prices, but create the entire book. Moreover, data transfer with these macros usually is only possible periodically like every minute, five minutes etc, while reconstruction allows screening in a continuous time. Furthermore, in most cases crude order data contain more details than the order book disseminated by information companies, which might be very useful in academic research.

There have already been some attempts to reconstruct the limit order book. Kavajecz (1999) constructs an estimate of the NYSE order book using TORQ database in four steps: identification of limit orders at the time the sample started (prebook); adding the current orders to the prebook; matching order records with execution records and matching order records with cancellations. He then obtains snapshots at 30-minute intervals. Goldstein and Kavajecz (2000 and 2004) replicate this methodology.

More recently, these attempts have been accelerated mostly for European exchanges. In their papers on the book analysis for Paris Bourse, Auguy and Le Saoût (1999 and 2001) and Auguy et al. (2000) briefly describe the RCO program prepared in SAS. Hall and Hautsch (2004) reconstruct the complete order book by replicating the electronic trading at the Australian Stock Exchange at each instant of time. Beltran et al. (2005) and Frey and Grammig (2005) do the reconstruction for DAX30 stocks with the same dataset from Xetra. Like Auguy and Le Saoût (1999 and 2001), they prepare two separate order books on Gauss

[2] See for instance Beltran et al. (2004).

program, one visible to traders and the other with iceberg orders[3] with snapshots each time a trade takes place. They are even able to distinguish the role of the stock member who trades: a broker (trading on behalf of the client), a dealer (trading for its own account) or a liquidity provider. Similarly, De Winne and D'Hondt (2005) very accurately reconstruct of order book for 82 selected stocks from Amsterdam, Brussels and Paris by using market members' ID codes and other privileged data in addition to the ones publicly available from Euronext.

Though such beneficial, reconstruction is not an easy task due to the complexity of order types and trading rules varying across markets. Moreover, data obtained from the stock exchanges usually are incomplete in the sense that some details such as buyer and seller names are kept confidential. In this paper, we try to show the key points one needs to consider in rebuilding the order book with application to Istanbul Stock Exchange (ISE). Besides, we discuss in what ways order book, once rebuilt, can help generate new variables useful in financial studies.

The organization of the paper is the following: Next section describes the market and data, Section III is about the reconstruction methodology, Section IV gives the output and the last section concludes.

II. Market and Data

Market

Istanbul Stock Exchange is a fully computerized order-driven market. In many respects, it is similar to Euronext, Hong Kong Stock Exchange or Australian Stock Exchange. Trading is

[3] One obvious advantage of order book reconstruction lies here.

continuous and the usual price and time priorities apply[4]. Nevertheless, some differences with the major order-driven exchanges do exist and can be summarized as follows.

i) There is no hidden order. Price and quantity of an order are fully displayed.

ii) Trading is continuous since the opening. So there is no any call auction at the opening or closing, nor a pre-opening session.

iii) Order revision is limited in the sense that a buy (sell) order in a particular stock cannot be cancelled if it is not the very last buy (sell) order sent to the system. Price of an order can be bettered (but not worsened), i.e. raised if it is a buy order and lowered if a sell order, which is a rule to facilitate trade execution. Order split is allowed though. So a waiting limit order can be divided into several pieces with different prices, but respecting the rule above.

iv) An 'order cross' occurs when two orders posted by the same brokerage house match. In that case, the trade which would soon take place is delayed for one minute if no any other order arrives and is executed thereafter. If another order at the same price level and direction arrives, if possible both orders are executed, otherwise the waiting limit order is shared according to some specific rules between these competitive market orders[5].

[4] A third priority rule is that if ever price and time of two orders sent by the same brokerage house are the same, the one coming from a customer has priority over the house's own order. But the ISE officials indicate that this situation does not happen in practice since the system is sensitive enough to distinguish between the times of very close orders.

[5] This rule was adopted in order to prevent manipulation.

v) Similarly to Madrid Stock Exchange, the names of brokerage houses in buy and sell sides of a transaction are displayed in the screens, which indicates a high level of post-trade transparency.

vi) Working hours are from 9.30 am to 16.30 pm in local time with a two-hour lunch break between 12 am and 14 pm. In other words, there are two trading sessions a day, one in the morning and one in the afternoon. Only electronic order submission is allowed in the first 15 (10) minutes of the morning (afternoon) session during which no any revision is possible. Orders can be submitted both electronically and non-electronically (via brokers in the floor) afterwards with possible modifications described in iii).

The available order types are:

-Limit Buy or Limit Sell[6] with the option of *kill the rest* (KTR)[7].

-Special (bloc) order with limited price: A kind of market buy (sell) order that satisfies all the waiting orders up (down) to the specified price level.

-Special (bloc) order with limited value: A special order with or without limited price, but also with a specified limited value. Anyway, the value of a single trade cannot exceed YTL 1.5 mn (almost $1.1 mn)[8].

One should consider all of the facts above in working with the orders and order book on the ISE. These rules vary across markets. Anyway, the reconstruction process requires these

[6] There is no market order on the ISE at all. Only marketable limit orders, i.e. buy orders at the ask price or higher and sell orders at the bid price or lower, can be given to accomplish an immediate transaction. Nonetheless, we will often use the term *market order* instead of *marketable limit order* to keep it simple.

[7] If an order is KTR, it is immediately executed at the specified limit price or eliminated. In case of a partial execution, the remaining part does not become a limit order and is cancelled.

[8] For more detailed information about trading rules and order types, see ISE Trading Rules Report (Hisse Senetleri Alim-Satim Kilavuzu, 2005).

specific rules and especially the order types to be clearly defined and inserted into the computing program.

Data

Our dataset granted by the ISE consists of order and transaction data of Akbank (AKBNK), one of the major private banks in Turkey with a market capitalization of almost $ 7 bn and average daily trading value of $ 17 mn as of January 2004.

Crude order data consist of 10 columns, which show in addition to the name of the stock, the ID number, date, time (in seconds), type (Buy, Sell, Short Sale, Demand for cancel, Cancel, Split), quantity and validity of the order as well as the highest (lowest) price at which one is ready to buy (sell) and whether it is a kill-the-rest (KTR) type order. If an order is split into pieces, the part at the original price level stays with the same order ID and keeps its priority while the new parts are given new IDs and lose priority.

Crude transaction data, in their turn, are composed of 9 columns showing the name of the stock, the date, time, session, quantity, price and ID of the transaction as well as the IDs of the buy and sell orders which have been matched.

Samples of crude order and transaction data are in Appendices B.1. and B.2. Clearer definitions of the above variables are in Appendices C.1. and C.2.

III. Reconstruction Methodology

Our objective is to convert the above order and transaction data into the order book in the way traders observe in their screens. In the second step, we will obtain a new dataset containing useful variables for financial analyses.

We developed a program in Java™ platform called BorsaSim in order to process the crude data and prepare the order book. This program first creates new files of order and transaction data by chronologically sorting the crude data, cutting the unnecessary items (for instance orders with quantity smaller than 1000 shares[9] (1 lot in the old terminology)). Then, it uses these two files to incorporate every order according to the priority rules and fills in the order book one by one. As argued below, if some orders match and are executed, they are first displayed onto and then eliminated from the order book. A row might indicate a new order, a revision (including split) or cancellation if these last two satisfy the rules.

The biggest challenge appears to be dealing with order crosses. Normally, the system of the stock exchange can easily detect when there is a case of order cross. But since the brokerage house names are kept confidential to us, we cannot detect it with the order data. However, our system does not question the existence of order cross. We link the Buying Order IDs and Selling Order IDs in the transaction data to the Order IDs in the order data so as to eliminate orders from the current book in case of matching.

Having the order book reconstructed, we can visualize it at every step. Moreover, we can create new variables calculated with the data therein. First of all, we give a number to each row of order and of transaction. We define the state number, which rises by one at each row,

[9] Such orders have another market between themselves.

to be the sum of the order number and trade number. These numbers are chronological and specific to stock while order IDs and trade IDs given in the crude data are still chronological but for the whole orders and transactions on the stock exchange. Then order and trade numbers and IDs might well be used as alternative variables to measure the time of trades and orders. The reason we propose them as new variables is that they are more sensitive than 'time' variable which is given in seconds. In fact, in most markets there are very active periods in a day when several orders arrive within one second. By differencing these variables, we create new ones to measure intertrade duration. Another new variable is the ratio of Order ID to Trade ID. This shows the proportion of limit orders to market orders.

To detect whether an order is a limit order or market order, we check the actual bid and ask prices. If the newcoming buy (sell) order proposes a price higher (lower) than or equal to the ask (bid) price, we identify it as a market order. As a consequence, we also eliminate the methodological matter caused by order crosses. So, even if a trade is delayed due to the order cross rule, we define the related order as a market order.

Once the order book is accurately set up, several variables can be deduced such as bid and ask prices, volumes and numbers of orders at each price level of the bid and ask sides, volume-weighted bid and ask prices, separately for the first two, first five or all price levels as well as the balance between bid and ask for all these variables. Comparing the order book aggregates at two or five best prices with those at all the prices might disclose information as to how much the observed book represent the total book[10]. Moreover, it can be argued that the absolute change in weighted prices simply measure order aggressiveness better than what have been proposed by Biais et al. (1995) and their successors like Ranaldo (2004), Hall and

[10] In principle, we expect that the five best prices are highly representative in the ISE since the tick sizes are relatively high. However it is not the case for Paris Bourse (See Auguy and Le Saoût (1999). It is interesting to search this issue especially in decimalized markets.

Hautsch (2004) and De Winne and D'Hondt (2005) because in this set up, aggressiveness is determined not only by price but also by the quantity whatever the price is, hence the series are smoother. In this set-up, the cancellation of a huge buy order at the best bid price has a more impact on the market (i.e., is negatively aggressive) than the one at lower prices while Biais et al. attribute the same importance to all the cancellations or to all the limit buy (sell) orders below (above) the best bid (ask)[11]. In our scheme, any order is aggressive insofar as it increases or decreases the weighted prices[12].

An original point, which makes our order book distinct from those observed in traders' screens, is that we incorporate the transaction-committing order into the book. When a market order arrives, we first put it into the order book, in which case the bid-ask spread becomes null for an instant, and then remove it, instead of directly taking out the matching order from the book. With this alteration we make meet limit and market orders in a single basket and reflect the demand for or supply of stock more accurately. Thus, we can easily filter the statistics before, at the time when or after the transaction occurs. This procedure can help improve studies on realized spreads or price impact of trade.

If the crude order and transaction data described above contain very useful information, they need to be modified in many respects for the derived research to make sense. Therefore, we conduct four main manipulations while processing the data. First, we change the IDs of modified orders with the purpose of keeping chronology in this variable. These adjusted OIDs are defined to be the midpoint of the previous and subsequent orders' IDs. Thus, we assume

[11] Another bias in the measure of Biais et al. is that the price of a trade is not always equal to the one of the order which causes the trade (See the correction below).

[12] One drawback of weighted bid and ask series is that the total volume in the book is not the same all the time, early minutes of the day the book being quite empty. To deal with this problem, one can use the absolute percentage variation instead of the absolute level of variation to measure aggressiveness.

each order revision creates a new situation for the market. Second, we believe a correction is necessary for prices proposed by investors whence they are too aggressive and do not walk up or down in the book[13]. Otherwise, analyses on these price series would be considerably biased. Third, we carry out a similar modification on sizes of bloc orders with the KTR option[14]. Finally, as discussed above, in cases of a market order (the spread becomes zero), we integrate this last order in the calculations of the related variables. Then, for instance the aggregates for the five best prices become the ones for the six best prices, the sixth price being the one of the market order (See Appendix C.3.).

IV. Output

The views of output we obtain from the crude data are in Appendix D. After choosing the date on the left of the bar below, we specify the order number or trade number we want to reach so that the computing process starts. It is possible to monitor both the simple order book as traders do (Appendix D.1.) and the detailed book as the ISE officials can do (Appendix D.2.). By referring to the detailed bid and ask lists, it is even possible to analyze all the actual limit orders at any particular moment, for example before a very strategic trade takes place. Due to space limitations in a computer screen, only few variables are displayed in Statistics page, but we can easily export all the output data to a spreadsheet in text format[15].

[13] For instance, if an investor submits a sell order of 100 shares at 7.15 while current bid and ask are 7.40 and 7.45 with 63,189 and 48,542 shares respectively, we convert 7.15 to 7.40.

[14] For the above example, if an investor sends an order to sell 100,000 shares at 7.40 with the kill-the-rest option, in fact, he is aware that he will only sell 63,189 since the rest is soon eliminated. Consequently, in such a case we convert the order size to 63,189 instead of leaving 100,000.

[15] The time the software spends to reconstruct the order book and calculate new variables depends on the power of the computer. For a PC with a processor Pentium 4 (3 Ghz) and 1 Gb of RAM, it takes almost 1 minute to sort monthly data. To display the order book at the end of a day and prepare the related new dataset, it might spend up to 10-15 minutes depending on the number of orders and trades on that day (for an example of 5000 rows of orders and 2300 rows of transactions) as well as the complexity between them (especially order cross). It decelerates when it comes to afternoon, as it often has to go backward to check for some conditions. Even so, exporting to a spreadsheet is soon once the program stops calculating.

Part of the processed data we obtain as well as clear definitions of all the output variables are in Appendices B.3. and C.3., respectively. They consist of 66 columns and 5000 to 8000 rows a day with non-periodical snapshots. Note that once the output file is ready it is very easy to filter the data according to the desired characteristics, like choosing only market orders, short sales or the situations when the number of sell orders in the book is between 100 and 150. Besides the general output file, we create 1-second, 5-second, 15-sesond, 1-minute, 5-minute, 15-minute and 30-minute snapshots to allow periodical analysis.

In order to verify the accuracy of our output, we compared it to the order book data saved by macros from the Reuters screen during some days of October 2003. Except for a few cases, our output is exactly the same as what was displayed[16]. This shows the program works quite well and does not have any noteworthy problem.

V. Conclusion

Reconstructing the limit order book is a highly complicated and time-consuming task. However, it is very fruitful as it lets the creation of many new variables which are not held by financial researchers, yet are essential to understand the functioning of order-driven markets or which constitute better alternatives to the existing ones.

This paper discusses the benefits of order book reconstruction and establishes new variables that can be generated, through an application to Istanbul Stock Exchange. While general methodology of reconstruction remains the same for other markets, particular trading rules such as call auction and specific order types (like icebergs) would require modifications. There are a variety of variables for researcher use once the book is correctly rebuilt, some of

[16] Some temporary deviations might occur due to order cross. We could not detect the cause of a very few (1-2 out of 7000-8000 states) permanent deviations. It may be due to data errors. Anyway, this fact does not damage the functioning of our program since it flows till the end, but just negligibly biases our calculations.

which are proposed in this study, such as order and trade numbers and IDs as well as weighted bid and ask prices. In fact, some data companies provide forms of these variables by bars, charts etc., but these are usually not stocked.

More than simply reconstructing order book, this paper proposes a new method to link trades to orders, i.e. instant market orders (constituting the transaction book) to the stock of limit orders (order book). We hope this attempt contributes to the literature on order book by offering new empirical tools and thus to develop our understanding of the complex behavior of trading.

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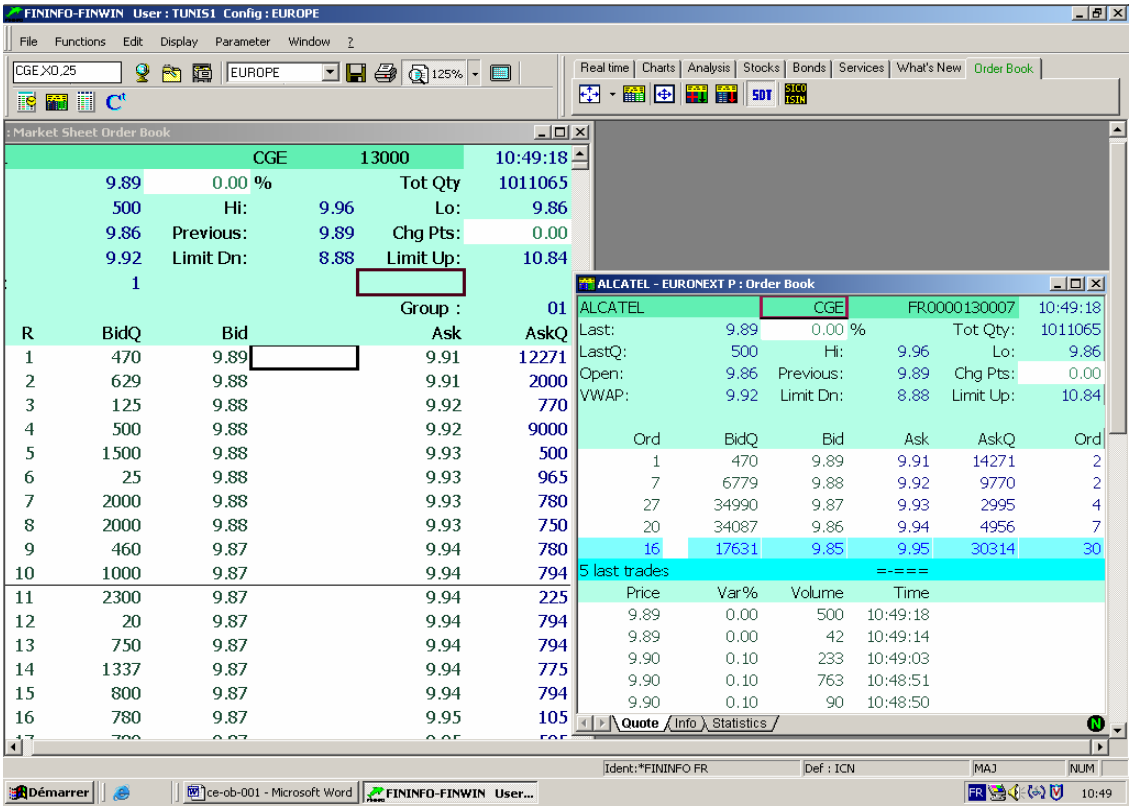
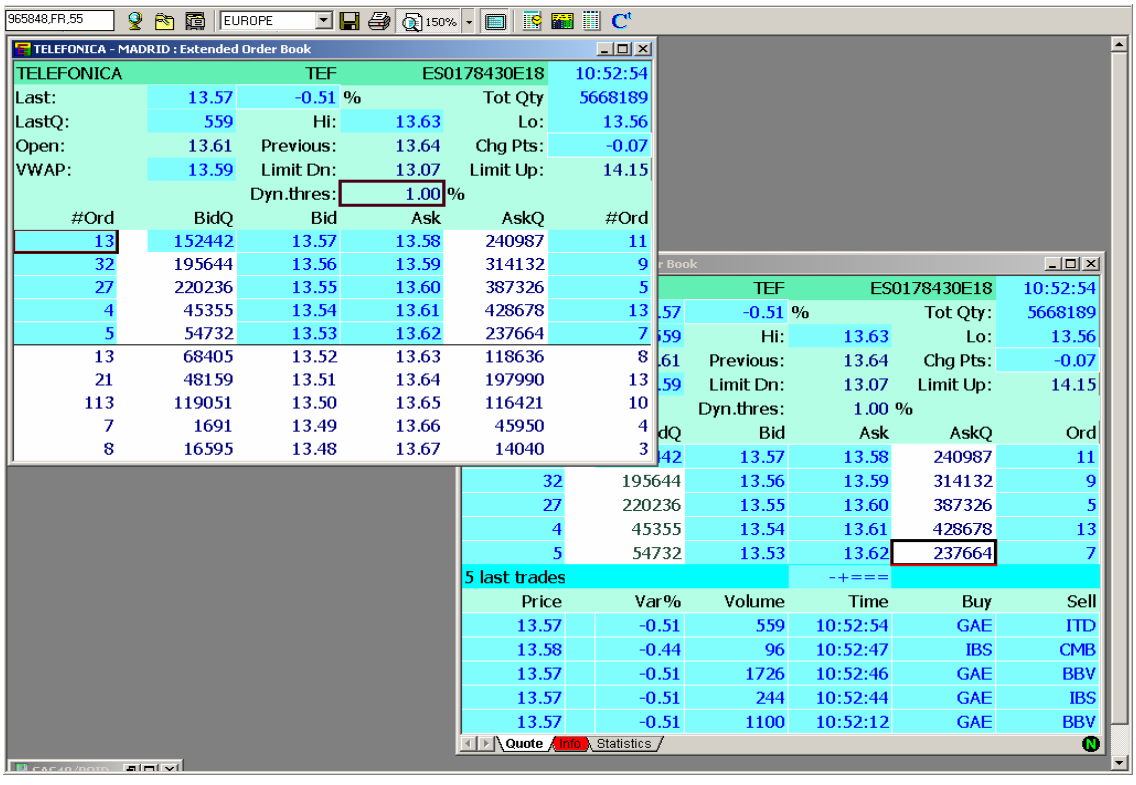
Appendix

A. Examples of Order Book

A.1. Alcatel share at Euronext Paris *(Source: Fininfo)*



A.2. Telefonica share at Madrid Stock Exchange *(Source: Fininfo)*



B. Examples of the Unprocessed and Processed Data

B.1. Part of the Order Data (Unprocessed)

ORDER ID	DATE	STOCK	ORDER TYPE	SHARES	PRICE	VALIDITY	TIME	KTR	SPLIT ORDER ID
201200400149208	01/02/2004	AKBNK	A	10000000	7450	0	14:11:06		
201200400149210	01/02/2004	AKBNK	A	10000000	7450	0	14:11:07		
201200400149233	01/02/2004	AKBNK	A	10000000	7450	0	14:11:07		
201200400149237	01/02/2004	AKBNK	A	10000000	7450	0	14:11:08		
201200400149255	01/02/2004	AKBNK	A	10000000	7450	0	14:11:08		
201200400092336	01/02/2004	AKBNK	C	50000	7400	01/04/2002	14:11:09		
201200400149266	01/02/2004	AKBNK	P	400000	7500	01/04/2002	14:11:09		201200400092336
201200400149284	01/02/2004	AKBNK	A	40000	7400	0	14:11:10		
201200400149336	01/02/2004	AKBNK	S	10000000	7550	0	14:11:13		
201200400149343	01/02/2004	AKBNK	S	20000	7500	0	14:11:13		
201200400149375	01/02/2004	AKBNK	S	300000	7600	1	14:11:15		
201200400149386	01/02/2004	AKBNK	A	1000000	7500	0	14:11:15		
201200400149561	01/02/2004	AKBNK	A	22000	7500	0	14:11:24		
201200400149575	01/02/2004	AKBNK	A	1000	7500	0	14:11:25		
201200400149893	01/02/2004	AKBNK	S	350000	7750	0	14:11:43		
201200400149950	01/02/2004	AKBNK	S	4000000	7550	0	14:11:46		
201200400149991	01/02/2004	AKBNK	S	15000	7550	0	14:11:48		
201200400150001	01/02/2004	AKBNK	A	4000000	7500	0	14:11:49		
201200400150128	01/02/2004	AKBNK	A	200000	7500	0	14:11:58		
201200400150141	01/02/2004	AKBNK	A	1500000	7400	0	14:11:59		
201200400150218	01/02/2004	AKBNK	A	200000000	7500	0	14:12:03	E	
201200400150220	01/02/2004	AKBNK	A	100000000	7500	0	14:12:03	E	
201200400150220	01/02/2004	AKBNK	W	100000000	7500		14:12:04	E	

B.2. Part of the Transaction Data (Unprocessed)

DATE	SEANS	TRADE ID	TIME	STOCK	PRICE	SHARES	BUYING ORDER	SELLING ORDER
01/02/2004	2	83461	14:11:09	AKBNK	7500	400000	201200400149266	201200400000614
01/02/2004	2	83535	14:11:15	AKBNK	7500	1000000	201200400149386	201200400000614
01/02/2004	2	83703	14:11:24	AKBNK	7500	22000	201200400149561	201200400000614
01/02/2004	2	83707	14:11:25	AKBNK	7500	1000	201200400149575	201200400000614
01/02/2004	2	83979	14:11:49	AKBNK	7500	739000	201200400150001	201200400000614
01/02/2004	2	83980	14:11:49	AKBNK	7500	3261000	201200400150001	201200400000892
01/02/2004	2	84097	14:11:58	AKBNK	7500	200000	201200400150128	201200400000892
01/02/2004	2	84169	14:12:03	AKBNK	7500	6539000	201200400150218	201200400000892
01/02/2004	2	84170	14:12:03	AKBNK	7500	10000000	201200400150218	201200400001124
01/02/2004	2	84171	14:12:03	AKBNK	7500	9269000	201200400150218	201200400001570
01/02/2004	2	84172	14:12:03	AKBNK	7500	5400000	201200400150218	201200400001679
01/02/2004	2	84173	14:12:03	AKBNK	7500	10000000	201200400150218	201200400001812
01/02/2004	2	84174	14:12:03	AKBNK	7500	600000	201200400150218	201200400001921
01/02/2004	2	84175	14:12:03	AKBNK	7500	3000000	201200400150218	201200400002023
01/02/2004	2	84176	14:12:03	AKBNK	7500	668000	201200400150218	201200400002677
01/02/2004	2	84177	14:12:03	AKBNK	7500	400000	201200400150218	201200400002699
01/02/2004	2	84178	14:12:03	AKBNK	7500	715000	201200400150218	201200400002816
01/02/2004	2	84179	14:12:03	AKBNK	7500	360000	201200400150218	201200400004588
01/02/2004	2	84180	14:12:03	AKBNK	7500	1000000	201200400150218	201200400004665
01/02/2004	2	84181	14:12:03	AKBNK	7500	500000	201200400150218	201200400006078

B.3. Part of the Output Data (Processed) – 1/5

StateNo	Date	OrderTime	OrderNo	TradeNo	OID	AOID	MOID	TID	DOID	DAOID	DTID	AOID/TID
2551	02/01/2004	14:11:07	1944	607	149210	149210		83385	2	2	0	1,789
2552	02/01/2004	14:11:07	1945	607	149233	149233		83385	23	23	0	1,789
2553	02/01/2004	14:11:08	1946	607	149237	149237		83385	4	4	0	1,789
2554	02/01/2004	14:11:08	1947	607	149255	149255		83385	18	18	0	1,789
2555	02/01/2004	14:11:09	1948	607	92336	149260		83385	-56919	5	0	1,79
2556	02/01/2004	14:11:09	1949	607	149266	149266		83385	56930	6	0	1,79
2557	02/01/2004	14:11:09	1949	608	149266	149266	614	83461	0	0	76	1,788
2558	02/01/2004	14:11:10	1950	608	149284	149284		83461	18	18	0	1,788
2559	02/01/2004	14:11:13	1951	608	149336	149336		83461	52	52	0	1,789
2560	02/01/2004	14:11:13	1952	608	149343	149343		83461	7	7	0	1,789
2561	02/01/2004	14:11:15	1953	608	149375	149375		83461	32	32	0	1,789
2562	02/01/2004	14:11:15	1954	608	149386	149386		83461	11	11	0	1,789
2563	02/01/2004	14:11:15	1954	609	149386	149386	614	83535	0	0	74	1,788
2564	02/01/2004	14:11:24	1955	609	149561	149561		83535	175	175	0	1,79
2565	02/01/2004	14:11:24	1955	610	149561	149561	614	83703	0	0	168	1,786
2566	02/01/2004	14:11:25	1956	610	149575	149575		83703	14	14	0	1,786
2567	02/01/2004	14:11:25	1956	611	149575	149575	614	83707	0	0	4	1,786
2568	02/01/2004	14:11:43	1957	611	149893	149893		83707	318	318	0	1,79
2569	02/01/2004	14:11:46	1958	611	149950	149950		83707	57	57	0	1,791
2570	02/01/2004	14:11:48	1959	611	149991	149991		83707	41	41	0	1,791
2571	02/01/2004	14:11:49	1960	611	150001	150001		83707	10	10	0	1,791
2572	02/01/2004	14:11:49	1960	612	150001	150001	614	83979	0	0	272	1,786
2573	02/01/2004	14:11:49	1960	613	150001	150001	892	83980	0	0	1	1,786
2574	02/01/2004	14:11:58	1961	613	150128	150128		83980	127	127	0	1,787
2575	02/01/2004	14:11:58	1961	614	150128	150128	892	84097	0	0	117	1,785
2576	02/01/2004	14:11:59	1962	614	150141	150141		84097	13	13	0	1,785
2577	02/01/2004	14:12:03	1963	614	150218	150218		84097	77	77	0	1,786
2578	02/01/2004	14:12:03	1963	615	150218	150218	892	84169	0	0	72	1,784
2579	02/01/2004	14:12:03	1963	616	150218	150218	1124	84170	0	0	1	1,784

Part of the Output Data (Processed) – 2/5

Dt	Shares	Price	Value	Validity	KTR	Type1	Type2	PB	PA	PA-PB	MS	PS	BV1	AV1	BV2
1	10000	7450	74500	1	N	A	L	7450	7500	50	7475	0,67	296312	295418	219514
0	10000	7450	74500	1	N	A	L	7450	7500	50	7475	0,67	306312	295418	219514
1	10000	7450	74500	1	N	A	L	7450	7500	50	7475	0,67	316312	295418	219514
0	10000	7450	74500	1	N	A	L	7450	7500	50	7475	0,67	326312	295418	219514
1	50	7400	370	2	N	C	L	7450	7500	50	7475	0,67	326312	295418	219114
0	400	7500	3000	2	N	P	M	7500	7500	0	7500	0,00	326712	295418	219114
0	400	7500	3000	2	N	P		7450	7500	50	7475	0,67	326312	295018	219114
1	40	7400	296	1	N	A	L	7450	7500	50	7475	0,67	326312	295018	219154
3	10000	7550	75500	1	N	S	L	7450	7500	50	7475	0,67	326312	295018	219154
0	20	7500	150	1	N	S	L	7450	7500	50	7475	0,67	326312	295038	219154
2	300	7600	2280	2	N	S	L	7450	7500	50	7475	0,67	326312	295038	219154
0	1000	7500	7500	1	N	A	M	7500	7500	0	7500	0,00	327312	295038	219154
0	1000	7500	7500	1	N	A		7450	7500	50	7475	0,67	326312	294038	219154
9	22	7500	165	1	N	A	M	7500	7500	0	7500	0,00	326334	294038	219154
0	22	7500	165	1	N	A		7450	7500	50	7475	0,67	326312	294016	219154
1	1	7500	7	1	N	A	M	7500	7500	0	7500	0,00	326313	294016	219154
0	1	7500	7	1	N	A		7450	7500	50	7475	0,67	326312	294015	219154
18	350	7750	2712	1	N	S	L	7450	7500	50	7475	0,67	326312	294015	219154
3	4000	7550	30200	1	N	S	L	7450	7500	50	7475	0,67	326312	294015	219154
2	15	7550	113	1	N	S	L	7450	7500	50	7475	0,67	326312	294015	219154
1	4000	7500	30000	1	N	A	M	7500	7500	0	7500	0,00	330312	294015	219154
0	739	7500	5542	1	N	A		7500	7500	0	7500	0,00	329573	293276	219154
0	3261	7500	24457	1	N	A		7450	7500	50	7475	0,67	326312	290015	219154
9	200	7500	1500	1	N	A	M	7500	7500	0	7500	0,00	326512	290015	219154
0	200	7500	1500	1	N	A		7450	7500	50	7475	0,67	326312	289815	219154
1	1500	7400	11100	1	N	A	L	7450	7500	50	7475	0,67	326312	289815	220654
4	200000	7500	1500000	1	E	A	M	7500	7500	0	7500	0,00	526312	289815	220654
0	6539	7500	49042	1	E	A		7500	7500	0	7500	0,00	519773	283276	220654
0	10000	7500	75000	1	E	A		7500	7500	0	7500	0,00	509773	273276	220654

Part of the Output Data (Processed) – 3/5

AV2	SBV2	SAV2	SBV2-SAV2	SBV5	SAV5	SBV5-SAV5	SABV	SAAV	BVT-AVT	WB2	WA2
161098	515826	456516	59310	722032	542995	179037	741031	614801	126230	7428,72	7517,64
161098	525826	456516	69310	732032	542995	189037	751031	614801	136230	7429,13	7517,64
161098	535826	456516	79310	742032	542995	199037	761031	614801	146230	7429,52	7517,64
161098	545826	456516	89310	752032	542995	209037	771031	614801	156230	7429,89	7517,64
161098	545426	456516	88910	751632	542995	208637	770631	614801	155830	7429,91	7517,64
161098	545826	456516	89310	752032	542995	209037	771031	614801	156230	7429,96	7517,64
161098	545426	456116	89310	751632	542595	209037	770631	614401	156230	7429,91	7517,66
161098	545466	456116	89350	751672	542595	209077	770671	614401	156270	7429,91	7517,66
171098	545466	466116	79350	751672	552595	199077	770671	624401	146270	7429,91	7518,35
171098	545466	466136	79330	751672	552615	199057	770671	624421	146250	7429,91	7518,35
171098	545466	466136	79330	751672	552915	198757	770671	624721	145950	7429,91	7518,35
171098	546466	466136	80330	752672	552915	199757	771671	624721	146950	7430,04	7518,35
171098	545466	465136	80330	751672	551915	199757	770671	623721	146950	7429,91	7518,39
171098	545488	465136	80352	751694	551915	199779	770693	623721	146972	7429,91	7518,39
171098	545466	465114	80352	751672	551893	199779	770671	623699	146972	7429,91	7518,39
171098	545467	465114	80353	751673	551893	199780	770672	623699	146973	7429,91	7518,39
171098	545466	465113	80353	751672	551892	199780	770671	623698	146973	7429,91	7518,39
171098	545466	465113	80353	751672	551892	199780	770671	624048	146623	7429,91	7518,39
175098	545466	469113	76353	751672	555892	195780	770671	628048	142623	7429,91	7518,66
175113	545466	469128	76338	751672	555907	195765	770671	628063	142608	7429,91	7518,66
175113	549466	469128	80338	755672	555907	199765	774671	628063	146608	7430,42	7518,66
175113	548727	468389	80338	754933	555168	199765	773932	627324	146608	7430,33	7518,69
175113	545466	465128	80338	751672	551907	199765	770671	624063	146608	7429,91	7518,82
175113	545666	465128	80538	751872	551907	199965	770871	624063	146808	7429,94	7518,82
175113	545466	464928	80538	751672	551707	199965	770671	623863	146808	7429,91	7518,83
175113	546966	464928	82038	753172	551707	201465	772171	623863	148308	7429,83	7518,83
175113	746966	464928	282038	953172	551707	401465	972171	623863	348308	7448,62	7518,83
175113	740427	458389	282038	946633	545168	401465	965632	617324	348308	7448,16	7519,10
175113	730427	448389	282038	936633	535168	401465	955632	607324	348308	7447,45	7519,53

Part of the Output Data (Processed) – 4/5

WA2-WB2	PWS2	WB5	WA5	WA5-WB5	PWS5	WBT	WAT	WAT-WBT	PWS	BO1	SO1	BO1-SO1
88,92	1,19	7396,05	7535,26	139,21	1,86	7389,64	7576,65	187,01	2,50	41	187	-146
88,52	1,18	7396,79	7535,26	138,47	1,85	7390,45	7576,65	186,20	2,49	42	187	-145
88,13	1,18	7397,50	7535,26	137,76	1,85	7391,23	7576,65	185,42	2,48	43	187	-144
87,75	1,17	7398,20	7535,26	137,06	1,84	7391,99	7576,65	184,66	2,47	44	187	-143
87,73	1,17	7398,20	7535,26	137,06	1,84	7391,99	7576,65	184,66	2,47	44	187	-143
87,68	0,01	7398,25	7535,26	137,01	0,02	7392,04	7576,65	184,61	2,47	45	187	-142
87,75	1,17	7398,20	7535,29	137,09	1,84	7391,99	7576,70	184,71	2,47	44	187	-143
87,75	1,17	7398,20	7535,29	137,09	1,84	7391,99	7576,70	184,71	2,47	44	187	-143
88,44	1,18	7398,20	7535,55	137,35	1,84	7391,99	7576,27	184,28	2,46	44	187	-143
88,44	1,18	7398,20	7535,55	137,35	1,84	7391,99	7576,27	184,28	2,46	44	188	-144
88,44	1,18	7398,20	7535,59	137,39	1,84	7391,99	7576,28	184,29	2,46	44	188	-144
88,31	0,01	7398,34	7535,59	137,25	0,02	7392,13	7576,28	184,15	2,46	45	188	-143
88,48	1,18	7398,20	7535,65	137,45	1,84	7391,99	7576,40	184,41	2,46	44	188	-144
88,48	0,01	7398,20	7535,65	137,45	0,02	7391,99	7576,40	184,41	2,46	45	188	-143
88,48	1,18	7398,20	7535,65	137,45	1,84	7391,99	7576,41	184,42	2,46	44	188	-144
88,48	0,01	7398,20	7535,65	137,45	0,02	7391,99	7576,41	184,42	2,46	45	188	-143
88,48	1,18	7398,20	7535,65	137,45	1,84	7391,99	7576,41	184,42	2,46	44	188	-144
88,48	1,18	7398,20	7535,65	137,45	1,84	7391,99	7576,50	184,52	2,47	44	188	-144
88,75	1,19	7398,20	7535,76	137,56	1,84	7391,99	7576,33	184,35	2,46	44	188	-144
88,75	1,19	7398,20	7535,76	137,56	1,84	7391,99	7576,33	184,35	2,46	44	188	-144
88,24	0,01	7398,74	7535,76	137,02	0,02	7392,55	7576,33	183,79	2,46	45	188	-143
88,37	0,01	7398,64	7535,80	137,16	0,02	7392,44	7576,42	183,98	2,46	45	187	-142
88,91	1,19	7398,20	7536,02	137,81	1,85	7391,99	7576,82	184,83	2,47	44	187	-143
88,89	0,01	7398,23	7536,02	137,79	0,02	7392,02	7576,82	184,81	2,47	45	187	-142
88,92	1,19	7398,20	7536,03	137,83	1,85	7391,99	7576,85	184,86	2,47	44	187	-143
89,00	1,19	7398,20	7536,03	137,82	1,85	7392,00	7576,85	184,84	2,47	44	187	-143
70,21	0,01	7419,56	7536,03	116,47	0,02	7414,22	7576,85	162,63	2,17	45	187	-142
70,94	0,01	7419,01	7536,46	117,45	0,02	7413,64	7577,66	164,02	2,19	45	186	-141
72,07	0,01	7418,14	7537,14	119,00	0,02	7412,74	7578,94	166,20	2,22	45	185	-140

Part of the Output Data (Processed) – 5/5

BO2	SO2	BO2-SO2	SBO2	SSO2	SBO2-SSO2	SBO5	SSO5	SBO5-SSO5	SABO	SASO	SABO-SASO
81	61	20	122	248	-126	212	351	-139	263	415	-152
81	61	20	123	248	-125	213	351	-138	264	415	-151
81	61	20	124	248	-124	214	351	-137	265	415	-150
81	61	20	125	248	-123	215	351	-136	266	415	-149
81	61	20	125	248	-123	215	351	-136	266	415	-149
81	61	20	126	248	-122	216	351	-135	267	415	-148
81	61	20	125	248	-123	215	351	-136	266	415	-149
82	61	21	126	248	-122	216	351	-135	267	415	-148
82	62	20	126	249	-123	216	352	-136	267	416	-149
82	62	20	126	250	-124	216	353	-137	267	417	-150
82	62	20	126	250	-124	216	354	-138	267	418	-151
82	62	20	127	250	-123	217	354	-137	268	418	-150
82	62	20	126	250	-124	216	354	-138	267	418	-151
82	62	20	127	250	-123	217	354	-137	268	418	-150
82	62	20	126	250	-124	216	354	-138	267	418	-151
82	62	20	127	250	-123	217	354	-137	268	418	-150
82	62	20	126	250	-124	216	354	-138	267	418	-151
82	62	20	126	250	-124	216	354	-138	267	419	-152
82	63	19	126	251	-125	216	355	-139	267	420	-153
82	64	18	126	252	-126	216	356	-140	267	421	-154
82	64	18	127	252	-125	217	356	-139	268	421	-153
82	64	18	127	251	-124	217	355	-138	268	420	-152
82	64	18	126	251	-125	216	355	-139	267	420	-153
82	64	18	127	251	-124	217	355	-138	268	420	-152
82	64	18	126	251	-125	216	355	-139	267	420	-153
83	64	19	127	251	-124	217	355	-138	268	420	-152
83	64	19	128	251	-123	218	355	-137	269	420	-151
83	64	19	128	250	-122	218	354	-136	269	419	-150
83	64	19	128	249	-121	218	353	-135	269	418	-149

C. Definitions

C.1. Definitions on the Order Data

ORDER ID: Identity (ID) number of the order

DATE: Date of the order

STOCK: Name of stock

ORDER TYPE: Type of the order (A: Buy, S: Sell, Q: Short Sell, C: Buy Order Price Revision (towards up), D: Sell Order Price Revision (towards down), T: Short Sell Order Price Revision (towards down), X: Buy Order Cancel Demand, Y: Sell Order Cancel Demand, W: Elimination of an order, P: Buy Order Split, R: Sell Order Split, L: Short Sell Order Split)

SHARES: Number of shares to be bought or sold (If ‘0’, it means all the shares available at that price level to be satisfied with the value limit of YTL 1.5 mn), excluding those smaller than 1000 (1 lot).

PRICE: Price of the order (in old Turkish Lira)

VALIDITY: Validity of the order (0 if one session, 1 or a date if both sessions (the whole day). Actually, even if a date appears in this column, all the orders are cancelled after the day close.

TIME: Time (in seconds) of the order

KTR: Kill-the-rest option (E if the order is of this type and N otherwise)

SPLIT ORDER ID: ID number of the order which is split into several orders

C.2. Definitions on the Trade Data

DATE: Date of the trade

SESSION: The session in which the transaction takes place (1 if TIME is between 9:30:00 and 12:00:00 and 2 if TIME is between 14:00:00 and 16:30:00)

TRADE ID: ID number of the trade

TIME: Time (in seconds) of the trade

STOCK: Name of the stock

PRICE: Transaction price

SHARES: Number of shares bought or sold, excluding those smaller than 1000

BUYING ORDER ID: ID number of the order which is on the buy side of a transaction

SELLING ORDER ID: ID number of the order which is on the sell side of a transaction

C.3. Definitions on the Output Data

StateNo: Any new situation. It is equal to the sum of OrderNo and TradeNo (See below)

Date: Date of the State

Time: Time in seconds of the State

OrderNo: It increases by 1 each time an order arrives or is revised, split or cancelled

TradeNo: It increases by 1 each time a match occurs

OID: Order ID (See above)

AOID: Adjusted OID

MOID: Matching Order ID

TID: Trade ID (See above)

DOID: Difference in OID

DAOID: Difference in AOID

DTID: Difference in TID

AOID/TID: Ratio of AOID to TID

Dt: Difference in Time

Shares: Shares of the order or the trade

Price: Price of the order or the trade

Value: Value (in YTL) of the order or the trade

Validity: Validity (See above)

KTR: Kill-the-rest type order (See above)

Type1: Order type (See above)

Type2: Shows the aggressiveness (L: Limit Order, M: Market Order). Empty if an order has been traded and before a new order arrives. 'C' if the order has been cancelled.

PB: Best Bid Price

PA: Best Ask Price

PA-PB: Difference between best ask and best bid prices (actual spread)

MS: Mid Spread, i.e. (PA+PB)/2

PS: Percentage Spread (or Relative Spread), i.e. [200x(PA-PB)/(PA+PB)]

BV1: Volume (number of shares) at the best bid price (becomes the volume at the two best bid prices if the actual order is a buy and causes a transaction)

AV1: Volume (number of shares) at the best ask price (becomes the volume at the two best ask prices if the actual order is a sell and causes a transaction)

BV2: Volume at the second best bid price (becomes the volume at the third best bid price if the actual order is a buy and causes a transaction)

AV2: Volume at the second best ask price (becomes the volume at the third best ask price if the actual order is a sell and causes a transaction)

SBV2: Sum of the volume at the two best bid prices (becomes the sum of the volume at the three best bid prices if the actual order is a buy and causes a transaction)

SAV2: Sum of the volume at the two best ask prices (becomes the sum of the volume at the three best ask prices if the actual order is a sell and causes a transaction)

SBV2-SAV2: Difference between SBV2 and SAV2

SBV5: Sum of the volume at the five best bid prices (becomes the sum of the volume at the six best bid prices if the actual order is a buy and causes a transaction)

SAV5: Sum of the volume at the five best ask prices (becomes the sum of the volume at the six best ask prices if the actual order is a sell and causes a transaction)

SBV5-SAV5: Difference between SBV5 and SAV5

SABV: Sum of the volume at all bid prices (the volume of the actual order is included if this is a buy order and causes a transaction)

SAAV: Sum of the volume at all ask prices (the volume of the actual order is included if this is a sell order and causes a transaction)

BVT-AVT: Total Bid Volume-Total Ask Volume

WB2: Average price weighted by the volume at the two (three if the above condition holds) best bid prices

WA2: Average price weighted by the volume at the two (three if the above condition holds) best ask prices

WA2-WB2: Difference between WA2 and WB2

PWS2: Percentage Weighted Spread at the two best price levels, i.e. [200x(WA2-WB2)/(WA2+WB2)].

WB5: Average price weighted by the volume at the five (six if the above condition holds) best bid prices

WA5: Average price weighted by the volume at the five (six if the above condition holds) best ask prices

WA5-WB5: Difference between WA5 and WB5

PWS5: Percentage Weighted Spread at the five best price levels, i.e. [200x(WA5-WB5)/(WA5+WB5)].

WBT: Average price weighted by the volume at all bid prices (the volume of the actual order is included if this is a buy order and causes a transaction)

WAT: Average price weighted by the volume at all ask prices (the volume of the actual order is included if this is a sell order and causes a transaction)

WAT-WBT: Difference between WAT and WBT

PWS: Percentage Weighted Spread at the aggregate level, i.e. [200x(WAT-WBT)/(WAT+WBT)].

BO1: Number of orders at the best bid price (becomes the number of orders at the two best bid prices if the actual order is a buy and causes a transaction)

SO1: Number of orders at the best ask price (becomes the number of orders at the two best ask prices if the actual order is a sell and causes a transaction)

BO1-SO1: Difference between BO1 and SO1

BO2: Number of orders at the second best bid price (becomes the number of orders at the third best bid price if the actual order is a buy and causes a transaction)

SO2: Number of orders at the second best ask price (becomes the number of orders at the third best ask price if the actual order is a sell and causes a transaction)

BO2-SO2: Difference between BO2 and SO2

SBO2: Number of orders at the two best bid prices (becomes the number of orders at the three best bid prices if the actual order is a buy and causes a transaction)

SSO2: Number of orders at the two best ask prices (becomes the number of orders at the three best ask prices if the actual order is a sell and causes a transaction)

SBO2-SSO2: Difference between SBO2 and SSO2

SBO5: Number of orders at the five best bid prices (becomes the number of orders at the six best bid prices if the actual order is a buy and causes a transaction)

SSO5: Number of orders at the five best ask prices (becomes the number of orders at the six best ask prices if the actual order is a sell and causes a transaction)

SBO5-SSO5: Difference between SBO5 and SSO5

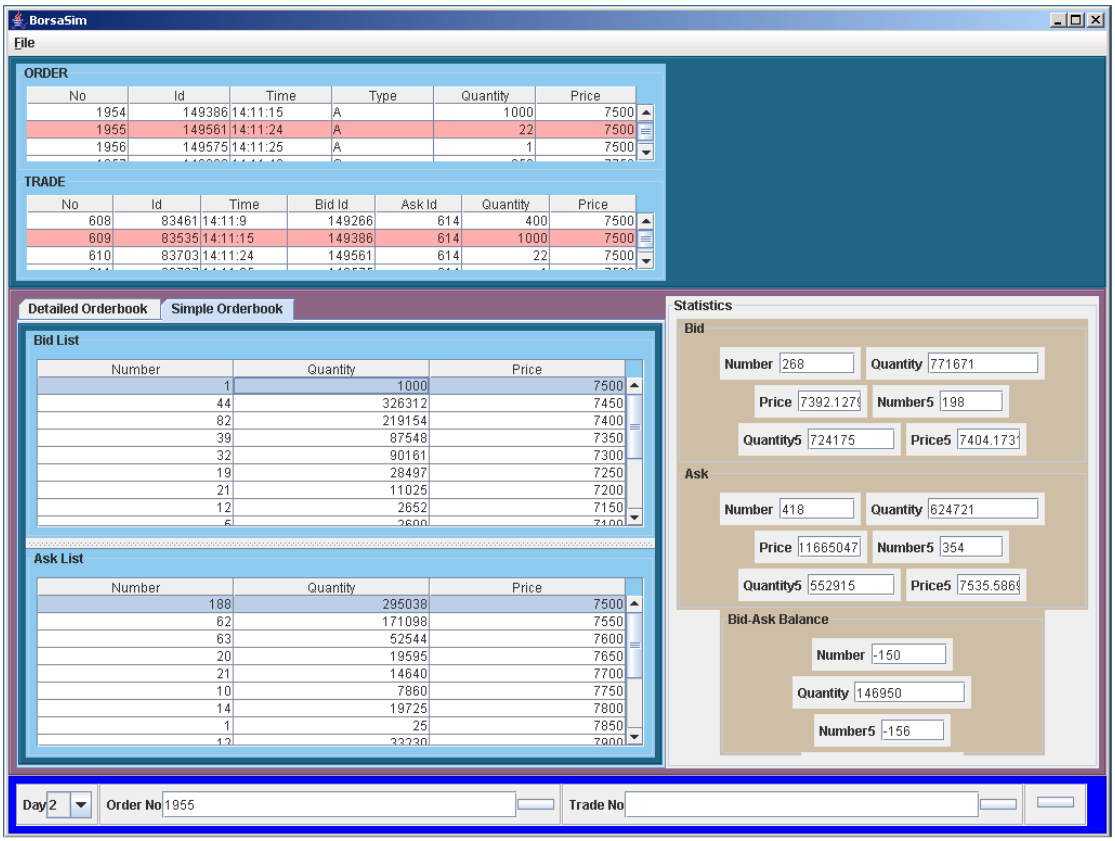
SABO: Total number of orders at all bid prices (the actual order is included if this is a buy order and causes a transaction)

SASO: Total number of orders at all ask prices (the actual order is included if this is a sell order and causes a transaction)

SABO-SASO: Difference between SABO and SASO

D. Views of the Java Program for Order Book Reconstruction (BorsaSim)

D.1. View of a simple order book



D.2. View of a detailed order book (showing each order separately)