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**An exploratory analysis of the order book, order flow and  
execution on the Athens stock market**

**By**

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**ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ  
ΑΘΗΝΩΝ**

**ΤΜΗΜΑ ΣΤΑΤΙΣΤΙΚΗΣ**

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**Κατράδη-Μέξη Σταυρούλα**

ΔΙΑΤΡΙΒΗ

Που υποβλήθηκε στο Τμήμα Στατιστικής  
του Οικονομικού Πανεπιστημίου Αθηνών  
ως μέρος των απαιτήσεων για την απόκτηση  
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## **CURRICULUM VITAE**

I was born in Athens in 1985. In 2003, I entered at the Panteion University of Social and Political Science, Department of Economics and Regional Development from where I graduated in 2007. During my studies I in two university researches of the Regional Development Institute .The first one was in cooperation with Piraeus Bank and the second with the Greek National Tourism Organization. In 2007 I was accepted to the preliminary stage of the full time Master in department of Statistics, in Athens University of Economics and Business. In 2008 I started courses to the full time Master in Statistics. In my free time I like very much spending time with my friends, doing sports and going to the cinema.

## **Abstract**

The recent availability of order, quote, and transaction data from stock markets around the world has stimulated research on intraday stock market phenomena. Intraday patterns identified in the data of US and other developed countries include the persistent U-shaped patterns in returns, number of shares traded, volumes, bid-ask spreads, and volatility. U-shaped patterns refer to the heavy trading activity on financial markets at the beginning and at the end of the trading day, and the relatively light trading activity over the middle of the day (Admati and Pfleiderer (1988)). For the US markets, these include studies by Wood et al. (1985), Jain and Joh (1988), McNish and Wood (1991, 1992), Brock and Kleidon (1992), Gerety and Mulherin (1992), Foster and Viswanathan (1993) and Chan et al. (1995a,b). McNish and Wood (1990) report similar results for the Toronto Stock Exchange and Lehmann and Modest (1994) and U-shaped patterns in trading for the Tokyo Stock Exchange.

Other studies that examine order-driven markets provide new evidence on patterns in the order book, order flow, and the interaction between the order book and order flow. A representative example is the empirical analysis by Biais et al. (1995) of the limit order book and order flow on the Paris Bourse. Niemeyer and Sandas (1995), Hedvall and Niemeyer (1996), Niemeyer and Sandas (1996) and Hedvall et al. (1997) perform similar analyses for stock markets in Stockholm and Helsinki.

In this thesis, we study the Athens Stock Market which was recently characterized as a developed market. The objective of this dissertation is at first to examine the behavior of market participants in the Stock Market. We try to understand the effect of order placement on market liquidity and to determine whether certain patterns can be generalized to other trading structures.

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# Chapter 1

## Basic terminology from microstructure analysis

We provide a glossary for financial terms to facilitate the reading of the thesis. If there is a need to understand some straightforward definitions of the financial tools and terms, this is the chapter that you might find functional and handy. Most entrepreneurs usually need to familiarize themselves with certain key terminology used in business financing, to be able to better plan and communicate the firm's financial position. There are a few and basic things you need to understand and they will probably clear up any confusion you may have reading the dissertation.

**Asset** means 1. A resource with economic value that an individual, corporation or country owns or controls with the expectation that it will provide future benefit. 2. A balance sheet item representing what a firm owns. Assets are bought to increase the value of a firm or benefit the firm's operations. You can think of an asset as something that can generate cash flow, regardless of whether it's a company's manufacturing equipment or an individual's rental apartment. In the context of accounting, assets are either current or fixed (non-current). Current means that the asset will be consumed within one year. Generally, this includes things like cash, accounts receivable and inventory. Fixed assets are those that are expected to keep providing benefit for more than one year, such as equipment, buildings and real estate.

**Audit Trail** means a step-by-step record by which accounting data can be traced to their source. The SEC and NYSE will use this method for the explicit reconstruction of trades when there are questions as to the validity or accuracy of an accounting figure. This is the technique used to track improper market activity. By documenting and analyzing all houses and brokers involved in specific trades, those who follow the audit trail can (hopefully) identify the culprit.

**Benchmark** is a standard against which the performance of a security, mutual fund or investment manager can be measured. Generally, broad market and market-segment stock

and bond indexes are used for this purpose. When evaluating the performance of any investment, it's important to compare it against an appropriate benchmark. In the financial field, there are dozens of indexes that analysts use to gauge the performance of any given investment including the S&P 500, the Dow Jones Industrial Average, the Russell 2000 Index and the Lehman Brothers Aggregate Bond Index.

**Bid-Ask Quote:** a two-way price comprises a [bid](#), or the price at which a [dealer](#) is willing to buy, and an ask (or [offer](#)) at which a dealer is willing to sell. The bid, by definition, is always below the ask and is always the first quoted price. The difference between the two quotes is known as the [spread](#). A spread between the best bid and best offer is called 'the [touch](#)'.

**Bond** is a legal contract in which a government, company or institution (the borrower) issues an IOU certificate, which promises to pay holders a specific rate of interest for a fixed [duration](#) and then redeem the contract at [face value](#) on [maturity](#). In theory bonds are safer than equities because they have a fixed maturity and are repaid before any payments are made to shareholders. But if a company fails, its bond holders suffer just as much as its shareholders.

**Book** is a record of all the positions that a trader is holding. This record shows the total amount of long and short position that the trader has undertaken.

**Commercial Paper** means an unsecured, short-term debt instrument issued by a corporation, typically for the financing of accounts receivable, inventories and meeting short-term liabilities. Maturities on commercial paper rarely range any longer than 270 days. The debt is usually issued at a discount, reflecting prevailing market interest rates. Commercial paper is not usually backed by any form of collateral, so only firms with high-quality debt ratings will easily find buyers without having to offer a substantial discount (higher cost) for the debt issue. A major benefit of commercial paper is that it does not need to be registered with the Securities and Exchange Commission (SEC) as long as it matures before nine months (270 days), making it a very cost-effective means of financing. The proceeds from this type of financing can only be used on current assets (inventories)

and are not allowed to be used on fixed assets, such as a new plant, without SEC involvement.

**Commodity** is a natural raw material used as a foodstuff or in manufacturing. Classified in the following groups: oil and gas metals; [grains](#) and oilseeds; soft commodities such as sugar, cocoa, coffee and tea; plantation crops such as rubber, palmoil, cotton and wool. [Exchange](#)-traded commodities are quoted in specific lots of a specific quality for specified delivery, and usually also trade in forward, [futures](#) and options contracts. Commodities traded outside organised exchanges usually change hands by direct contact between individual producers and individual end-users. The contracts are tailor-made for each deal and are often signed for a long-term continuing supply.

**Dealer:** 1. an individual or firm willing to buy or sell securities for their own account. 2. One who purchases goods or services for resale to consumers.

A dealer differs from an agent in that a dealer acts as a principal in a transaction. That is, a dealer takes ownership of assets and is exposed to inventory risk, while an agent only facilitates a transaction on behalf of a client.

**Depth** is the ability of a security to absorb buy and sell orders without the stock price dramatically moving in either direction. Securities with good depth will be relatively liquid, and large orders will not affect price significantly. On the other hand, securities with poor depth are more likely to have their price affected by large orders to buy and sell. To gauge the depth of a market, investors can search for the different prices and sizes (bid and ask sizes) of orders accumulating below and above the market bid and ask prices

**Designated Order Turnaround - DOT (SuperDOT)** is an electronic system that increases order efficiency by routing orders for listed securities directly to a specialist on the trading floor, instead of through a broker. It is also known as "SuperDOT." The DOT system is used by the New York Stock Exchange for small order entries, limit orders, and basket and program trades.

**Execution** is the completion of a buy or a sell order for a security. The execution of an order happens when it is completely filled, not when it is placed by the investor. When the

investor places the trade, it goes to a broker, who then determines the best way for it to be executed.

Brokers are required by law to give investors the best execution possible, and can attempt to execute the transaction in the following ways: 1. Order to the Floor: This can take some time as it goes through human hands. The floor broker will need to get the order and fill it. 2. Order to Market Maker: On exchanges such as the Nasdaq, market makers are in charge of different stocks. The investor's broker may direct the trade to one of these market makers for execution. 3. Electronic Communications Network (ECN): an extremely quick method, whereby computer systems electronically match up buy and sell orders. 4. Internalization: If the broker's firm holds an inventory of the stock in question, it may decide to execute the order from its own inventory.

**Exchange Rate** means the price of one country's currency expressed in another country's currency. In other words, the rate at which one currency can be exchanged for another. For example, the higher the exchange rate for one euro in terms of one yen, the lower the relative value of the yen. In most financial papers, currencies are expressed in terms of U.S. dollars, while the dollar is commonly compared to the Japanese yen, the British pound and the euro. As of the beginning of 2006, the exchange rate of one U.S. dollar for one euro was about 0.84, which means that one dollar can be exchanged for 0.84 Euros.

**Flipper** is: 1. A short-term investor or day trader who buys pre-IPO shares, swiftly spinning them out into public markets for a quick profit. 2. A real estate participant who purchases a home renovates it and sells it for a profit a short time later.

Flippers may hold a stock for only 24-48 hours, and therefore are very susceptible to any immediate downturns or upturns in the market. These sudden market shifts can make or break a day trader, whereas a long-term investor could much more easily weather the ups and downs of stormy stocks. Real estate flippers are battling a whole minefield of problems in order to make some big cash. Problems with borrowing, insurance, renovations, inspections, market conditions and more can make a huge dent in the tens of thousands of dollars they could make on one flip.

**FTSE** is a company that specializes in index calculation. Although not part of a stock exchange, co-owners include the London Stock Exchange and the *Financial Times*.

The FTSE is similar to Standard & Poor's in the United States. They are best known for the FTSE 100, an index of blue-chip stocks on the London Stock Exchange.

**Future** is an undertaking to buy or sell a standard quantity of a financial asset or [commodity](#) at a future date and at a fixed price. Futures resemble [forwards](#), but are standardized contracts (ie. every futures contract has standardized terms that dictate the size, the unit of price [quotation](#), the delivery date and contract months) and must be traded on a recognized [exchange](#). Price movements are expressed in ticks (the smallest unit of price quotation). Delivery of a future is rare. As the delivery date draws near, most investors close out their positions by undertaking an equal and opposite trade. The futures markets bring together hedgers who wish to protect themselves against the rise or fall of prices, and speculators who are trying to benefit from such movements. A [clearing house](#) acts as the counter party in every transaction to protect against the [risk](#) of [default](#), so the buyer and seller do not have to deal directly with each other. Futures developed as a method for establishing forward purchase prices and managing price instability caused by seasonal factors in agricultural markets. Today, [interest rate](#) and [stock index](#) futures attract the greatest volume.

**Limit Order** is an order placed with a brokerage to buy or sell a set number of shares at a specified price or better. Limit orders also allow an investor to limit the length of time an order can be outstanding before being canceled. Depending on the direction of the position, limit orders are sometimes referred to more specifically as a buy limit order, or a sell limit order. Limit orders typically cost more than market orders. Despite this, limit orders are beneficial because when the trade goes through, investors get the specified purchase or sell price. Limit orders are especially useful on a low-volume or highly volatile stock.

**Market Order** means an order to buy or sell a stock immediately at the best available current price. A market order is sometimes referred to as an "unrestricted order". A market order guarantees execution, and it often has low commissions due to the minimal work brokers need to do. You must be wary of using market orders on stocks with a low average

daily volume: in such market conditions the ask price can be a lot higher than the current market price (resulting in a large spread). In other words, you may end up paying a whole lot more than you originally anticipated. It is much safer to use a market order on high-volume stocks.

**Option** is a financial derivative that represents a contract sold by one party (option writer) to another party (option holder). The contract offers the buyer the right, but not the obligation, to buy (call) or sell (put) a security or other financial asset at an agreed-upon price (the strike price) during a certain period of time or on a specific date (exercise date). Options are extremely versatile securities that can be used in many different ways. Traders use options to speculate, which is a relatively risky practice, while hedgers use options to reduce the risk of holding an asset. In terms of speculation, option buyers and writers have conflicting views regarding the outlook on the performance of an underlying security. For example, because the option writer will need to provide the underlying shares in the event that the stock's market price will exceed the strike, an option writer that sells a call option believes that the underlying stock's price will drop relative to the option's strike price during the life of the option, as that is how he or she will reap maximum profit. This is exactly the opposite outlook of the option buyer. The buyer believes that the underlying stock will rise, because if this happens, the buyer will be able to acquire the stock for a lower price and then sell it for a profit.

**Order imbalance** is a situation resulting from an excess of buy or sell orders for a specific security on a trading exchange, making it impossible to match the buyers' and sellers' orders. For securities that are overseen by a market maker or specialist, shares may be brought in from a specified reserve to add liquidity, temporarily clearing out excess orders from the inventory so that the trading in the security can resume at an orderly level. Extreme cases of order imbalance may cause suspension of trading until the imbalance is resolved. Order imbalances can often occur when major news hits a stock, such as an earnings release, change in guidance, or merger and acquisition activity. Imbalances can move securities to the upside or downside, but most imbalances get worked out within a few minutes or hours in one daily session. Smaller, less liquid securities can have imbalances that last longer than a single trading session because there are fewer shares in the hands of fewer people. Investors can protect themselves against the volatile price

changes that can arise from order imbalances by using limit orders when placing trades, rather than market orders.

**Security** means an instrument representing ownership (stocks), a debt agreement (bonds) or the rights to ownership (derivatives). A security is essentially a contract that can be assigned a value and traded. Examples of a security include a note, stock, preferred share, bond, debenture, option, future, swap, right, warrant, or virtually any other financial asset.

**Spread** has several different meanings: 1. The difference in a price [quotation](#) between the [bid](#), the price at which a [dealer](#) is prepared to buy, and the ask, the price at which a dealer will sell. A large spread usually means the market lacks [liquidity](#). When a market lacks liquidity dealers often cannot buy and sell quickly and so they widen the spread to avoid being caught on the wrong side of the market. 2. Spread can also be used to express the difference in yields between two [fixed income](#) securities of the same quality but different maturities, or of different quality but the same maturities. 3. Often 'spread' refers to the difference in [yield](#) between a [bond](#) and a reference government bond, which is regarded as relatively [risk](#)-free. 4. A [futures](#) spread is the difference in prices between delivery months in the same or different markets. 5. Spread can also refer to the difference between borrowing and lending rates by which a financial intermediary makes profits.

**Stock** is 1. The amount of [money](#) employed by a company in its work-in-progress, in raw materials and in finished goods. Also known as [inventory](#). 2. A stock represents part ownership of a company and the right to receive a share in the profits of that company. Also called a [share](#).

**Stock split** is a corporate action in which a company's existing shares are divided into multiple shares. Although the number of shares outstanding increases by a specific multiple, the total dollar value of the shares remains the same compared to pre-split amounts, because no real value has been added as a result of the split. In the U.K., a stock split is referred to as a "scrip issue", "bonus issue", "capitalization issue" or "free issue". For example, in a 2-for-1 split, each stockholder receives an additional share for each share he or she holds. One reason as to why stock splits are performed is that a company's share



price has grown so high that to many investors, the shares are too expensive to buy in round lots. For example, if a XYZ Corp.'s shares were worth \$1,000 each, investors would need to purchase \$100,000 in order to own 100 shares. If each share was worth \$10, investors would only need to pay \$1,000 to own 100 shares.

**Tick** means the minimum upward or downward movement in the price of a security.

**Touch** is the best (highest) [bid](#) and (lowest) [offer](#) for a given [security](#) in the current market. This need not be the two-way price of one [market maker](#) but is taken by looking at the market prices submitted by all market makers.

**Trade** is the voluntary exchange of [goods](#), [services](#), or both. Trade is also called [commerce](#). A mechanism that allows trade is called a [market](#). The original form of trade was [barter](#), the direct exchange of goods and services. Later one side of the barter were the metals, precious metals (poles, coins), bill, paper money. Modern traders instead generally negotiate through a medium of exchange, such as [money](#). As a result, buying can be separated from selling, or [earning](#). The invention of money (and later credit, paper money and non-physical money) greatly simplified and promoted trade. Trade between two traders is called bilateral trade, while trade between more than two traders is called multilateral trade. Trade exists for man due to specialization and division of labor, most people concentrate on a small aspect of production, trading for other products. Trade exists between regions because different regions have a [comparative advantage](#) in the production of some tradable commodity, or because different regions' size allows for the benefits of [mass production](#). As such, trade at [market prices](#) between locations benefits both locations.

In [finance](#), a trader is someone who buys and sells [financial instruments](#) such as [stocks](#), [bonds](#) and [derivatives](#). It is important to understand that a broker who simply fills buy or sell orders is not a trader, as they are merely executing instructions given to them.

**Transaction** is an agreement between a buyer and a seller for the exchange of goods or services for payment. The parties participating in a transaction have an obligation to perform their part. For example, for two parties involved in a futures contract, the seller is obligated to sell and deliver the underlying asset and the buyer is contractually obligated to pay the agreed upon price and accept the delivery.

**Transparency** means the extent to which investors have ready access to any required financial information about a company such as price levels, market depth and audited financial reports. Classically defined as when "much is known by many", transparency is one of the silent prerequisites of any free and efficient market. When transparency relates to information flow from the company to investors, it is also known as "full disclosure". Transparency helps to prevent the corruption that inevitably occurs when a select few have access to important information, allowing them to use it for personal gain. Reduced price volatility also tends to be a byproduct of a transparent market because all the market participants can base decisions of value on the same data. There are dozens of federal regulations in place to ensure transparency in our markets. Companies also have a strong motivation to provide disclosure, as transparency is generally rewarded through the stock's performance.

**Treasury Stock (Treasury Shares)** is the portion of shares that a company keeps in their own treasury. Treasury stock may have come from a repurchase or buyback from shareholders; or it may have never been issued to the public in the first place. These shares don't pay dividends, have no voting rights, and should not be included in shares outstanding calculations.

Treasury stock is often created when shares of a company are initially issued. In this case, not all shares are issued to the public, as some are kept in the companies' treasury to be used to create extra cash should it be needed. Another reason may be to keep a controlling interest within the treasury to help ward off hostile takeovers. Alternatively, treasury stock can be created when a company does a share buyback and purchases its shares on the open market. This can be advantageous to shareholders because it lowers the number of shares outstanding. However, not all buybacks are a good thing. For example, if a company merely buys stock to improve financial ratios such as EPS or P/E, then the buyback is detrimental to the shareholders, and it is done without the shareholders' best interests in mind.

**Volume** is the number of shares or contracts traded in a security or an entire market during a given period of time. It is simply the amount of shares that trade hands from sellers to buyers as a measure of activity. If a buyer of a stock purchases 100 shares from a

seller, then the volume for that period increases by 100 shares based on that transaction. Volume is an important indicator in technical analysis as it is used to measure the worth of a market move. If the markets have made strong price move either up or down the perceived strength of that move depends on the volume for that period. The higher the volume during that price move the more significant the move.

**Warrant** means a derivative security that gives the holder the right to purchase securities (usually equity) from the issuer at a specific price within a certain time frame. Warrants are often included in a new debt issue as a "sweetener" to entice investors. The main difference between warrants and call options is that warrants are issued and guaranteed by the company, whereas options are exchange instruments and are not issued by the company. Also, the lifetime of a warrant is often measured in years, while the lifetime of a typical option is measured in months

## **Chapter 2**

### **A review of related articles**

In chapter 2 of the diplomatic thesis, I document some of the recent papers which have common elements with my research. I mainly present articles that they have been published or written after 2000. Moreover, I choose papers that authors used limit order book or TAQ database in their models because I use the same kind of database in my study. Finally, I try to categorize the articles, based on what they examine. The review of literature usually becomes a link between the research proposed and the studies already done. It actually needs to be done even before the research project is formalized. This is essential to make sure that you are not repeating the work that someone has already done earlier. Occasionally, the work may be exact repetition of the work done earlier, but with a different set of data or sources of facts, and purpose of the research may just be see if your results are similar to earlier works or otherwise. This dissertation belongs to the second category.

### **2.1 Liquidity**

Liquidity is the degree to which an asset or security can be bought or sold in the market without affecting the asset's price. It is characterized by a high level of trading activity. Assets that can be easily bought or sold, are known as liquid assets. Also the ability to convert an asset to cash quickly is known as "marketability". There is no specific liquidity formula, however liquidity is often calculated by using liquidity ratios. It is safer to invest in liquid assets than illiquid ones because it is easier for an investor to get his/her money out of the investment. Examples of assets that are easily converted into cash include blue chip and money market securities.

**Al-Suhaibani Mohammad, Kryzanowski Lawrence, “An exploratory analysis of the order book, and order flow and execution on the Saudi stock market”**

In this article they study the Saudi Stock Market. Their main purpose is to examine how the market participants behave in this Stock Market. Also they investigate how order placement affects market liquidity. They use intraday data on firm orders, order packages, quotes and transactions from the Saudi Stock Market (SSM). They first find that SSM include U-shaped patterns in traded volume, in the placement of new orders, number of transactions and volatility. They also find that the average relative inside spread is large compared to other markets because there is a relatively high tick size.

The relative spread of SSM is higher only at the open and declines gradually. Finally they find that liquidity is relatively low on the SSM.

### **Biais Bruno et al, “An Empirical Analysis of the Limit Order Book and the Order Flow in the Paris Bourse”**

This article examines the placement of limit orders and investigates their effect on liquidity and price formation. They study how the order flow and some informational events that happen in the market place react to the state of the order book. Their database concludes the history of order book and order flow. They show the presence of order traders in the market which they monitor the order book, compete to provide liquidity to the market when it is needed and rewarded, and quickly seize favorable trading opportunities. They find different ways in which bid and ask quotes collect the information content of large trades in a limit order market

### **Chordia Tarun et al, “Market Liquidity and Trading Activity”**

In this paper, they construct time series of market-wide liquidity measures and market-wide trading activity. Their database is almost 2,800 trading days over the eleven-year period 1988-1998. The data are more than 1300 NYSE stocks on each trading day. This article examines aspects of aggregate market liquidity and trading activity and attempt to identify influential determinants of these phenomena. They find that there is a strong relation between market-wide liquidity and market-wide trading activity. They also find that they can do predictions in changes of liquidity using market returns.

### **Grullon Gustavo et al, “Advertising, Breadth of Ownership, and Liquidity”**

The sample of the study consist the firms that have available data on the Center for Research in Security Prices (CRSP) and the trades and quotes (TAQ) database for at least one year over the period 1993-1998. The paper document the impact of firms’ advertising expenditures on breadth of ownership and stock liquidity. They analyze the relationship between liquidity and advertising expenditures in a multivariate model that has controls other factors that may affect liquidity. They test the relation between advertising and breadth of ownership and the relation between advertising and several measures of stock market liquidity.

### **Chordia Tarun et al, “Order Imbalance, Liquidity, and Market Returns”**

Their aim is to examine the tri-partite association among trading activity, liquidity, and stock market returns using a lengthy and recent set of high frequency data. This article shows that there is a strong contemporaneous association between stock returns and order imbalance. Also there is evidence that market prices tend to reverse following declines and continue following previous up-moves. Finally order imbalance also has an impact on contemporaneous volatility above and beyond the well-known influence of trading volume. This is the first study to analyze daily order imbalances for a comprehensive sample of stocks over a long sample period. Their results generally indicate that imbalances affect liquidity and returns not just at the individual stock level but at the aggregate market level as well.

## **2.2 Volatility**

Volatility refers to the amount of uncertainty or risk about the size of changes in a security's value. A higher volatility means that a security's value can potentially be spread out over a larger range of values. This means that the price of the security can change dramatically over a short time period in either direction. A lower volatility means that a security's value does not fluctuate dramatically, but changes in value at a steady pace over a period of time. One measure of the relative volatility of a particular stock to the market is

its beta. A beta approximates the overall volatility of a security's returns against the returns of a relevant benchmark (usually they use S&P 500). For example, a stock with a beta value of 1.1 has historically moved 110% for every 100% move in the benchmark, based on price level. Conversely, a stock with a beta of .9 has historically moved 90% for every 100% move in the underlying index.

**Liu Yanhui et al, “Statistical properties of the volatility of price fluctuations”**

Their analysis uses S&P 500 index from the New York Stock Exchange (NYSE) consists of 500 companies chosen for their market size, liquidity, and industry group representation in the U.S. They try to examine the statistical properties of volatility, measured by locally averaging over a time window  $T$ , the absolute value of price changes over a short time interval  $\Delta t$ . They find that the probability density function of the volatility of this database is well fitted by a log-normal distribution in the central part and in the tail by a power law. Finally in order to quantify correlations in the volatility they use detrended fluctuation analysis and the power spectrum.

**Massa Massimo, Simonov Andrei, “Reputation and interdealer trading. A microstructure analysis of the Treasury Bond Market.”**

This paper presents how trader's reputation help to explain volume and volatility in terms of market impact of trades originated by otherwise identical traders. They examine this issue by investigating the role that dealers' reputation played on the mechanism of price formation. Their database contains all transactions from September 1994 to February 1996 for all listed bonds. They conclude that the same type of trade, on the same asset, in the same market can generate different volume and volatility patterns, depending on the type of dealers who originating it. Also the reputation and how the dealers interact depend on the information existing in the market and on the degree of disclosure that dealers deal with.

## 2.3 Behavioral finance

A field of finance that proposes psychology-based theories to explain stock market unexpected results under a given set of assumptions. Within behavioral finance, it is assumed that the information structure and the characteristics of market participants systematically influence individuals' investment decisions as well as market outcomes. Behavioral finance has two building blocks, the first is the cognitive psychology and the second is the limits to arbitrage. Cognitive refers to how people think and limits to arbitrage refers to predicting in what circumstances arbitrage forces will be effective, and when they won't be. Behavioral finance is not a separate discipline, but instead will increasingly be part of mainstream finance. There have been many studies that have documented long-term historical phenomena in securities markets that contradict the efficient market hypothesis and cannot be captured plausibly in models based on perfect investor rationality.

### **Bacidore Jeffrey et al, “Order submission strategies, liquidity supply, and trading in pennies on the New York Stock Exchange”**

Using NYSE system order data, this article examines how decimal pricing affect trader behavior, displayed liquidity supply, and execution quality. They study 128 pilot securities' trading activity and they collect order, quote and trade data for the pilot stock. They present that although traders do not reduce their use of limit orders in favor of market orders or non-displayed orders, they do decrease limit order size and cancel limit orders more frequently after decimals than before. This reduction show the existence of liquidity, however, does not manifest itself in poor execution quality. Maintaining execution quality in the face of less displayed liquidity implies that floor traders supplement the liquidity in the limit order book more frequently.



**Massa M., Drudi F., “Asymmetric information and trading strategies: testing behavior on the primary and secondary T.-Bond markets around caution days.”**

They examine how traders behave when faced the possibility of trading in two different markets characterized by different degrees of transparency. They use a database from the Italian bond market which records the behavior of each single Treasury bond dealer both markets (primary and secondary). They show the affection of the simultaneous existence of a less transparent market on the market depth of the more transparent one. They identified the optimal trading strategy and argued that, depending on the features of the less transparent market, this strategy may involve price manipulation. They argued that both strategies (hiding and price manipulation) increase market depth in the more transparent market.

**Glosten Lawrence R. , “Is the Electronic Open Limit Order Book Inevitable?”**

This analysis describes some characteristics of the equilibrium in an electronic market when there are a large number of limit orders submitters. They use a general model of investor behavior .It is shown that the order book has a small-trade spread and that the open limit order book provides as much liquidity as possible in the extreme situations. Also that the limit order book does not invite competition from third market dealers and if the actual costs of running an exchange are small, then among exchanges that operate continuously and anonymously, and supply nice marginal price schedules, the electronic exchange is the only one that does not tend to engender additional competing exchanges.

**Lee Charles M.C., Radhakrishna Balkrishna , “Inferring investor behavior: Evidence from TORQ data”**

They believe that studying observed trades and quotes you can arrive at a conclusion about market participants. They use TORQ database from the New York Exchange.

The analysis based on: 1.the mapping between orders and trades which deals with the basic reliability of trades as proxies for investor orders, 2. whether a trade is initiated by a buyer or a seller and 3. the usefulness of trade-size. They suggest that frequency, size and direction of observed trades can contribute to evaluate the incoming flows of market

orders. They show that relationship between orders and traders are more complex than previous articles suggest. Also a large number of reported trades cannot be totally classified as either buyer or seller initiated. Finally they show that trade size is still highly effective in separating institutional and individual investor activities.

**Manaster Steven, Mann Steven C., “Life in the Pits: Competitive Market Making and Inventory Control”**

This study uses audit trail transaction records for all Chicago Mercantile Exchange (CME) future trades from the first half of 1992. They examine the cross-sectional inventory behavior and the relationship between the inventors and the prices. They use a simple model of minute by minute inventory time series behavior consistent with inventory control models. The findings of this article are that market makers manage the level of their inventories but the predictions that concern price and inventory together are contradicted to their data. Also they verified empirically that price responds to the information content of order flow.

**Sofianos George, Werner Ingrid M. , “The trades of NYSE floor brokers”**

They examine the contribution of floor brokers to the Exchange’s floor-based auction market. In this study, they focus on the part of floor-broker-represented orders that are actively traded by floor brokers. They study the factors that influence the participation rates of specialists and floor brokers in a regression framework. Their data on floor broker trades come from the NYSE's internal audit trail file (CAUD). The sample covers the period January 2 through February 28, 1997 and consists of all NYSE trades in 110 NYSE common stocks. They estimate pooled (that has observations over time for several different units or cross-sections) time-series cross-sectional GMM regression for all except nine stocks of the sample. Also they estimate separate regression for three groups which are most liquid (deciles 9-10), medium liquidity (deciles 5-8), and least liquid (deciles 1-4). All the results in this article show that floor brokers are very important part of the NYSE auction market and the researchers must take account of the presence of floor brokers.

### **Hansch Olivier et al, “Do inventories matter in dealership markets? Evidence from the London Stock Exchange”**

This paper examines the predictions of inventory models which pertain to the relative inventory position of dealers. Also it presents empirical results on interdealer trading and the relationship between interdealer trading and dealer inventory levels. Their database is a sample of the most liquid stocks of the London Stock Exchange and contains quotes and transactions. They show that dealers with extreme inventory positions execute large orders which move their inventories to desired levels. Also a big part of order flow goes to the market makers, posting the most competitive quotes. They found a significant relationship between quote changes and inventory changes. Finally they show that the inventory level of a dealer is related with the extent to which the dealer takes part in interdealer trades.

## **2.4 Price dynamics**

### **Maslov Sergei, Mills Mark , “Price fluctuations from the order book perspective—empirical facts and a simple model”**

This analysis uses the high frequency data collected in the NASDAQ Level II system. Any model in order to understand the price fluctuation needs a mechanism for the formation of the price. In this study they use empirical market impact function, linear/non linear, which reduces calculating prices to knowing the imbalance between the supply of and the demand for the stock at any given time step. This paper examines the statistical properties and dynamics of published displayed limit orders. They next concentrate on calculating the depth of the order book at any given bid and ask level because the depth of the order book is an important measure of the liquidity of the market for a particular stock. Finally a large imbalance in the number of limit orders at the highest bid and lowest ask sides of the book leads to a predictable average price change which is in accord with intuitive notions regarding supply and demand.

### **Chakravarty Sugato, “Stealth-trading: Which traders’ trades move stock prices?”**

Using in their analysis TORQ data which include information about trades, quotes, order processing, and audit trails for a random sample of NYSE stocks, they first show a result consistent to the “stealth-trading” hypothesis. Stealth-trading hypothesis shows that medium-size trades display a disproportionately large cumulative price change relative to their overall proportion of trades and/or volume. They show that the source of the disproportionately is due to medium size trades initiated by institutions. Finally they find evidences that medium size institutional trades contribute to the overall cumulative price impact of medium-size trades. This is also evident in the universe of TORQ stocks.

### **Chan Soon Huat et al, “Price Limit Performance: Evidence from Transactions Data and the Limit Order Book”**

This paper uses data from Kuala Lumpur Stock Exchange’s 30 percent price limit system. Also their study makes use of transactions data and the limit order book. They examine the effect of price limits on information asymmetry, arrival rates of informed traders, and order imbalance. They identify that that price limits do not improve information asymmetry, delays the arrival of information, and cause order imbalances prior to and after a limit-hit. Also they show that markets with a wide price limit band, price limits do not improve market efficiency, but impose costs.

### **Rosu Ioanid , “A dynamic model of the limit order book”**

This article presents a model of price formation in a market where agents trade through a limit order book. They use a model of an order-driven market which explains the increase of market prices from the interaction of a large number of traders, who arrives at the market at random. This model is tractable which generates many predictions about the shape of the limit order book and the evolution of buy and sell prices or of the bid-ask spread. It shows that buy and sell orders can cluster away from the bid-ask spread, thus generating a hump-shaped limit-order book. Also, this paper show that even in the absence of asymmetric information a market buy order would increase not only the ask price, but also the bid price.

**Weber Philipp, Rosenow Bernd , “Order book approach to price impact”**

They use data from the Island ECN, NASDAQ's largest electronic communication network, which comprises about 20 percent of all trades. They use 10 stocks which are the most frequently traded for the year 2002. They document the price changes causing from buying and selling stocks. These changes are described from the price impact function. They find that the virtual price impact function as calculated from the average order book is convex and increases much faster than the concave price impact function for market orders. This difference can be explained by taking into account dynamical properties of the order book, i.e. the average net order flow and the strong anticorrelation between returns and limit order flow

**Evans Martins D.D., Lyons Richard K , “Order flow and Exchange Rate Dynamics”**

This paper presents the microeconomics of asset pricing. This direction makes available a rich set of models from the field of microstructure finance. Their data includes all the DM/\$ and ¥/\$ transactions that occurred from May 1 to August 31, 1996, on an interdealer trading system called Reuters Dealing 2000-1. All trades on this system take the form of electronic bilateral conversation. Their analysis is focused on order flow which is mainly affect prices. Traditional approaches, with their common-knowledge environments, admit no role for information aggregation. Their findings suggest instead that the problem this market solves is indeed one of information aggregation.

**Bollerslev Tim, Zhang Benjamin Y.B. , “Measuring and modeling systematic risk in factor pricing models using high-frequency data”**

The data sources of this paper include the Trade And Quote (TAQ). The TAQ database is from the New York Stock Exchange, and contains intraday trades and quotes for all securities listed on the NYSE, AMEX, and NASDAQ stock markets. This article documents how the systematic risk in standard multi-factor asset pricing models may be assessed more precisely through the use of high-frequency data and realized volatility measures. They use the three-factor Fama–French model and a set of size and book-to-market sorted portfolios.

## **2.5 Execution Costs**

Execution Costs is the difference between the execution price of a security and the price that would have existed in the absence of a trade, which can be further divided into market impact costs and market timing costs. The execution costs of a single complicated trade is typically the difference between the final average trade price, including commissions, fees and all other costs, and a suitable benchmark price representing a hypothetical perfectly executed trade.

### **Hansch Olivier et al, “Preferencing, Internalization, Best Execution, and Dealer Profits”**

This article provides direct and comprehensive evidence of the effect of preferencing and internalization on quality of execution and the probability of market making in a competitive dealership market. They use a wide variety of data from the London Stock Exchange (LSE). They examine whether a particular type of order flow is more profitable to the market makers. Their results show that preferenced trade receive worse execution than nonpreferenced and internalized trades receive better execution than noninternalized, after controlling factors such as the size of trade, the width of the inside spread, short-run volatility, liquidity, etc. They also suggest that practices like preferencing and internalization are at best necessary but not sufficient to lead to collusive profits.

### **Jones Charles M., Lipson Marc L. , “Sixteenths: direct evidence on institutional execution costs”**

In this study they use proprietary data set of institutional orders to measure the effect of this tick size reduction on realized execution costs. They use a proprietary data set of institutional orders. They measure execution costs for a sample of institutional equity orders providing by a consulting firm. This sample contains all client equity trades of this firm in NYSE-listed stocks within 100 trading days of the NYSE change to sixteenths. They fit execution costs to order, manager, and market characteristics, and then compare pre-sixteenths and post-sixteenths residuals. Specifically, we run firm-by-firm regressions

using only pre-sixteenths orders, regressing the total execution costs of an order on a vector of order and manager characteristics. This shows that institutional trading costs increase with the adoption of sixteenths by the NYSE. They also find that many kinds of orders and institutions are not essentially affected by the tick reduction. Finally their evidence concludes that the reduction of tick size causes spread fall and this reduces market makers surplus on small orders.

**Bessembinder Hendrik, Eccles David , “Issues in Assessing Trade Execution Costs”**

The sample was selected is a set of 300 NYSE and 4241 Nasdaq listed common stocks. This study conducts sensitivity analysis to determine the practical importance of some methodological issues that arise when you measure trade execution costs using the publicly-available quotation and trade price databases. The first methodological choice is the method used for classify trades as resulting from customer buy versus sell orders, and the second is the relationship between trade report times and the time of the quote chosen as a reference point. Generally they show that estimated trading costs increase if trade prices are compared to earlier rather than contemporaneous quotes, reflecting adverse quote movements prior to trade report times. Also they show that trade direction and rates of price improvement are best assessed when making no allowance for trading reporting lags.

## **2.6 IPO (initial public offering)**

Initial Public Offering - IPO is the first sale of stock by a private company to the public. IPOs are often issued by smaller, younger companies seeking the capital to expand, but can also be done by large privately owned companies looking to become publicly traded. In an IPO, the issuer obtains the assistance of an underwriting firm, which helps it determine what type of security to issue (common or preferred), the best offering price and the time to bring it to market. Also referred as a "public offering". IPOs can be a risky investment. For the individual investor, it is tough to predict what the stock will do on its initial day of trading and in the near future because there is often little historical data with which to

analyze the company. Also, most IPOs are of companies going through a transitory growth period, which are subject to additional uncertainty regarding their future values.

**Krigman Laurie et al, “The Persistence of IPO Mispricing and the Predictive Power of Flipping”**

They use sample of IPOs, for which they have Securities Data Companies (SDC) variables such as offering date, number of shares offered, offer price, lead underwriter, and Center for Research in Security Prices (CRSP) daily return and volume information, covers 1,232 IPOs. This paper examines underwriters’ pricing errors and the information content of the first-day trading activity in IPOs. They show underwriters fail to adjust their estimates of a firm’s value when they price a security relative to the preliminary price range. Also they show that the first-day return and the level of flipping on the first day predict the performance of IPO stocks over the next year. They conclude that flipping of IPOs is a reasonable behavior because flippers quickly sell a stock that perform the worst in the future, and they sell less in the best future performing stocks.

**Sherman Ann E., Titman Sheridan , “Building the IPO order book: underpricing and participation limits with costly information”**

This paper investigates the book building process which is being used throughout the world to distribute initial public offerings (IPOs). Their model explains why investment banks reduce the number of investors that are invited to participate in an IPO. The model is based on two assumptions. Firstly the collection of information is costly and second there are economics profits related with generating as much information as possible. They show that when the cost of information is less the number of investors is infinite and underpricing approaches zero.

## **2.7 Order book**

An order book is a list of open unshipped customer orders, normally time-phased and valued at actual individual order priced, that may include margin and profitability analysis.



Order book may also refer to the system (generally a computer system) operated by many Stock Exchange for storing and matching the various kinds of order (such as limit orders or market orders) that can be placed on such an exchange.

**Harris Lawrence E., Panchapagesan Venkatesh, “The information content of the limit order book: evidence from NYSE specialist trading decisions”**

Using SuperDOT limit orders in the TORQ database (the TORQ database contains transactions, quotes, order processing data and audit trail data for a sample of NYSE stocks) this paper examines whether the limit order book is informative whether specialists use this information in their discretionary actions and whether relative tick size helps explain cross-sectional differences in specialist trading decisions. They find that the limit order book is informative about future price changes. They also find strong evidence that the specialist uses information from option values more than from quantities in his decision to stop a market order, or trade with it. The results from the cross-sectional regression show that the tick size affects the competition between the specialist and limit order traders to offer liquidity. The results are more evident for active stocks where the competition between specialists and limit order traders is more intense.

**Bouchaud Jean-Philippe et al, “Statistical properties of stock order books: empirical results and models”**

Using order book of three liquid stocks of the Paris Bourse, in this article they study the statistics of these order book, which is a very important part of financial markets. In this study they investigate the statistical properties of the order book, such as the distribution of incoming limit orders, the average shape of the order book in the moving reference frame of the price, or the distribution of volume at the bid/ask. They document the price at which incoming limit orders are placed. Also they show that the distribution of volume at the bid/ask is very broad and can be fitted by a Gamma distribution. Finally the maximum of the most of order book is away from the bid/ask and a tail reflecting the statistics of the new limit orders.

## **Cornelli Francesca, Goldreich David ,“Bookbuilding: How Informative is the Order Book?”**

The purpose of this paper is to examine how the investment bank uses the information in the book when setting the issue price and whether this information can help predict subsequent secondary aftermarket prices. They find that there is a very strong relationship between the limit prices submitted by bidders and the issue price for IPOs and seasoned equity offerings (SEOs). They also find that oversubscription and aftermarket returns in IPOs are positively related and this also happens with the elasticity of the demand and the aftermarket returns. But there is a negative relationship between elasticity and the aftermarket volatility. Finally they find some evidence when the price of a seasoned equity offering differs from its premarket price, the aftermarket price tends to revert to the premarket level.

## **2.8 Limit order book**

Limit order book means a record of unexpected limit orders maintained by the specialist. The specialist has the responsibility to guarantee that the top priority order is executed before other orders in the book, and before other orders at an equal or worse price held or submitted by other traders on the floor (floor brokers, market makers, etc)

## **Kavajecz Kenneth A., “A Specialist's Quoted Depth and the Limit Order Book”**

This study explains why specialists use depth as a strategic choice variable in order to determine the amount of liquidity they provide. They also find an estimator of the public limit order book as it is an important supplier of liquidity and a competitor to specialists. They use a TORQ (trades, orders, reports, quotes) database which includes 144 NYSE listed securities over a three month period. Their findings show that specialists and limit order traders reduce depth around information events, thereby reducing their exposure to adverse selection costs. Also specialists' quotes reflect only the limit order book on the side of the market where they believe there is a chance of informed trading.

### **Baruch Shmuel, “Who Benefits from an Open Limit-Order Book?”**

In this paper, they develop a model to address the welfare implications of making the limit-order book visible prior to market opening and they investigate the implications of the changes in the transparency. They use a model of a specialist’s single price auction in two different conditions. In the first the limit-order book is open and in the other is closed. In their model, liquidity traders submit market orders. Their results show that, when the market is large enough, opening the limit-order book reduces the price impact of market makers. Also they show that, on average, prices reveal more information when the book is open, implying lower post-open volatility. Finally they show that closing the limit-order book the limit order traders extract more rents, and numerical analyses indicate that the specialist is better off in the closed-book situation.

## **2.9 Limit order Market**

### **Goettler Ronald L. et al, “Equilibrium in a Dynamic Limit Order Market”**

In this paper, they use a model to determine the reasons that traders choose between buy and sell orders, and market and limit orders. They investigate the relationships between transaction prices, transaction costs, trader surplus, and some of the commonly used proxies. The model is a stochastic dynamic game in which each agent chooses an action only once, upon entry to the market. Is a discrete time model of a pure limit order market for an asset. They find that the midpoint of the quoted spread is an unbiased proxy for the consensus value, on average, in the model. Finally, they find that supply and demand of liquidity are endogenous, so the effective spread is not a good measure of surplus.

### **Rinaldo Angelo, “Order Aggressiveness in Limit Order Book Markets”**

This article examines the relationship between trading aggressiveness and order flow in a pure, order-driven market, using a unique data set from the Swiss stock exchange. It shows that the state of the order book affect trader’s quotation decisions. The results of the econometric model show that patient traders become more aggressive when the own

(opposite) side book is thicker (thinner), the spread size wider, and the transient price volatility higher. Finally the results show that the buy and the sell sides of the book affect the order submission differently.

## **2.10 Miscellaneous**

### **Kairys Josheph P. et al, “A table of three cities: Is an Electronic Public Order Appropriate for Transition Economies?”**

In this paper they examine the daily experience of three stock exchanges in the formerly planned economies of Poland, Lithuania and Latvia, each of which adopted an electronic public order book developed in cooperation with the Paris Bourse. These exchanges provided daily trading results for each security traded, with an indication of the market segment where trading occurred. This article tries to examine the evolution of these three stock exchanges. They begin their analyses by studying the effect of the introduction of continuous variable price trading, the last major innovation in the market microstructure of the stock exchanges in Warsaw, Vilnius, and Riga. They document the different responses of these markets to this innovation in the trading mechanism.

### **Engle Robert F., Lunde Asger , “Trades and Quotes: A Bivariate Point Process”**

Traders buy and sell assets and in order to determine their strategies they observe posted prices and previous transactions. Specialists post quotes and in order to decide which quote they will post, they observe past transactions and prices. Transactions and the observation of quotes do not occur simultaneously. So the times of each event represent some optimization and potentially convey information. This paper analyses these two time scales and estimates a model that relates them. They developed a bivariate model of the new trades and quotes for stocks traded on the NYSE. The data are from trade and quote database. The time between a trade and a new price quote is an interesting measure of the speed at which information is included into prices. It is also related to the price impact of the trade, the liquidity of the stock, and ultimately, the volatility of the stock.

### **Schultz Paul , “Stock Splits, Tick Size and Sponsorship”**

This paper uses a large number of intraday trades and quotes for a sample of 235 stocks that split between April 1993 and March 1994 from NYSE. They show that promote or sponsor following splits is consistent with stocks. Also this paper provides evidences that stock splits increase the shareholder base for a stock and that market makes more profits if it follows splits, because the spread for all trade sizes for almost all stocks increases. Furthermore, the increase in spread contributes to the decline of the costs of making markets. Finally they document that following splits provide to trading errors decline.

### **Ellis Katrina et al, The Accuracy of Trade Classification Rules: Evidence from Nasdaq**

Using data from the Nasdaq market they examine pricing behavior, market design, and other microstructure phenomena. They examine the validity of several trade classification algorithms. They find that the quote rule, the tick rule and the Lee-Ready rule correctly classify 76.4%, 77.66% and 81.05% of the trades, respectively. They also show that the tick rule performed reliably better than the quote rule for trades away from the quotes, and using the tick rule for all trades away from the quotes, and the quote rule for trades at the quotes provides an improvement over the Lee-Ready algorithm.

## **Chapter 3**

### **An exploratory analysis of the order book, and order flow and execution on the Athens stock market**

#### **3 Introduction**

A longtime review of literature told us about aspects that have already established or concluded by other authors. In 2000 the Journal of Banking and Finance published the paper “An exploratory analysis of the order book, and order flow and execution on the Saudi stock market” written by Mohammad Al-Suhaibani and Lawrence Kryzanowski. It is interested because common analysis has not been undertaken earlier on the Athens stock market. This chapter is an exploratory analysis of listed stocks on the Athens stock market, based on the published paper.

This chapter has several unique aspects. First, the ASM, which is described in detail in the next section, is a market where a lot of listed stocks trade very passively for long periods during the day, making the information asymmetry contained inside the sign traded volume a more important factor than either the trade or the volume individually. Second, the transaction data set were drawn from intraday files of the ASE for the May 21, 2009 and for the period from November 26, to December 3, 2008. It included 13 listed stocks and their time-stamped prices to the nearest second, volumes, and bid and offer prices with corresponding prices just before a transaction occurs, for all transactions. Third, this thesis applies well-known methodologies of exploratory analysis in order to provide evidence related to the order book and order flow, which adds to the existing empirical literature on order-driven markets. The literature on market microstructure often discusses liquidity measures such as width, depth and immediacy that may have more relevance for market-order traders. Our data set allow us to examine liquidity measure on the ASM such as width, depth, resiliency, and immediacy that may have more relevance for market-orders traders.

Our analysis is organized into four sections. The first section offers a brief description of this Market with respect to its general characteristics, the organization of the Main and Secondary Markets, and its trading mechanisms. The data sets are described in Section 2.

Section 3 presented descriptive statistics of order book. Chapter 4 generalizes our findings in data that includes information for stocks for more than one day.

### **3.1 The Athens Stock Exchange – a general description**

The Athens Stock Exchange (ASE) is a joint stock company operating according to a set of local laws and regulations, and to all European Union capital market directives. The Athens stock exchange was first established in 1876. It is a semi-government institution under the control of ministry of commerce (Panas 1992). Athens Exchange is a subsidiary of Hellenic Exchanges S.A., whose shares are listed in ATHEX. In August 1999 the derivatives market started operating, and in 2002 the Athens Stock Exchange and the Athens Derivatives Exchange merged to form Athens Exchange.

At the end of 2002, approximately 375 companies were listed in it, with a total capitalization approaching e 85.5 billion. ASE members include security brokerage houses, credit institutions and investment service companies that have been granted a license by the Bank of Greece or by the Capital Market Commission. Only ASE Members can execute purchase and sale orders for shares through the Integrated Automatic Electronic Trading System (OASIS) of the market. Members are under the obligation to (a) keep the ASE informed of their realized transactions on a daily basis, (b) keep the Capital Market Commission informed on the use of their own funds, loans and shares on a 3 weekly basis, (c) disclose to the same Commission their larger financial exposure and solvency ratio on a monthly basis, (d) issue transaction slips for all completed transactions and (e) follow the accounting and tax laws.

Five different market segments currently operate inside the ASE: (i) The Main Market, (ii) the Parallel Market, (iii) the New Market (NEHA), (iv) the Greek Market of Emerging Companies (EAGAK), and finally, (v) the Secondary Listings on the ASE from Stock Exchanges outside Greece. The main classification rule for any company to be listed in the first four segments is the amount of their own equity. Companies wishing to issue stocks in the Main Market are subject to more stringent conditions than those in the Secondary Market. Three major stock indices are calculated on a daily basis:

1. The **ASE General**, a market cap-weighted index, represents the general trend of the Greek stock market and its composition criteria include capitalization, transactions value and shares marketability.
  2. The **FTSE/ASE - 20** is the large Cap Index, featuring the 20 largest blue chip companies. Companies are included in it on the basis of their capitalization and their free float.
  3. The **FTSE/ASE Mid 40** follows the performance of the next 40 larger companies.
- The last two indices cover approximately 2/3 of the total market capitalization of the ASE Main Market.

A variety of basket indices have been constructed for the ASE. Two of the most important indices, the constituents of which are reviewed every six months, are the General Index of the Main Market (GIDX) and the Secondary Market General Index (SCIDX). Trading hours are 11 a.m. to 4 p.m., Monday through Friday, with a half-hour pretrading session from 10:30 a.m., to 11 a.m. and a posttrading session from 4 p.m. to 4:30 p.m. All transactions are in cash, and they are performed on exchange without the intervention of market makers. Trades are conducted electronically through an automated exchange trade system (OASIS) that has evolved from the electronic trading system which is already in use in Spain, and which ensures continuous operation 24-hours-a-day throughout the year. Anonymous trading is provided in the Main, Secondary, and Derivatives Markets, with automatic matching of orders and selective matching in the form of 'hit-and-take'. The computerized system is capable of handling 50.000–60.000 orders per hour. Trading halts are automatically imposed on specific stocks when their price fluctuation on a particular day exceeds 10% in either direction. Price limits do not apply during the first three days of a company's listing. Trading fees are fixed at 0.6% of each transaction value, while commissions are set freely by the trading parties.



## 3.2 The data sets

The data set provided by Athens Stock Exchange consists of intraday data on firm orders for 20 stocks listed on the market from one trading day (21 May 2009). Because the results of these paper can be easily generalized to any of these 20 stocks, we used at first in our analyses only one, ETE (national bank of Greece). Our first data set included all the transactions from 10:35 a.m. to 5 p.m.. Due to a half pre-trading session and a half post-trading session, the transactions that investors did in these periods, are excluded. Also we excluded the transactions that they have zero quotes (bids and asks). For each order, the data set reports the time of creation, limit price position, quantity, turnover and the first five best ask and the first five best bid.

From these final data sets we construct three different panels of data in order to help our analyses. The first data set (panel A) includes the limit price position and the quantity for each order. We construct a second data set (panel B) containing all the quotes (bids and asks). This panel has two groups, the one is the total number of asks and the other is the total number of bids. The third group (panel C) is similar with the second but the only difference is that each group does not include the first best ask/bid. The number of transaction in our sample is 3128. Table 3.1 presents some summary statistics for each of four data sets. Panel A in Table 3.1 reports summary statistics for the order data set.

Trades may be classified into buys and sells using the following technique (Engle and Lunde). Trades at prices above the midquote are associated with buys (initiated by a buyer) and are given a value of 1. Trades below the midquote are called sells (initiated by a seller) and are given a value of -1. This variable is often referred to as a buy-sell trade indicator. The rationale for this classification is that trades originating from buyers are most likely to be executed at or near the ask, while sell orders trade at or near the bid. This scheme is classifies all trades except those that occur at the midquote. We do not apply the tick rule. Trades at the midquote are given a value of zero. This result in the following value

$$sign_i = \begin{cases} 1 & \text{if } p_i > (ask_i + bid_i) / 2 \\ 0 & \text{if } p_i = (ask_i + bid_i) / 2 \\ -1 & \text{if } p_i < (ask_i + bid_i) / 2 \end{cases} .$$

The percentage of buy is less than the percentage of sell orders. Their difference is big enough. As the most of the orders in the data set are sells, the statistics of the sell orders is almost equal with the summary statistics of the whole first data set.

The summary statistics of Panel A and Panel B have very small differences because the values of the first best ask and bid, are close enough to the values of the other quotes. Table 3.2 provides summary statistics for each quote. Comparing the means we can conclude that the values of bids increases that the values of asks decreases. This process lead to the conclusion that the first best ask, the first best bid and the limit price position are almost equal.

Table 3.2 provides descriptive statistics for each quote of panel B. As we move from B5 to B1 the descriptive statistics incline and respectively from A5 to A1 decline. This is usually happens because B1 is the highest quoted bid for a particular quote and A1 is the lowest quoted ask, among all those offered by competing market makers. The best ask and the best bid, are the quotes before the transaction takes place.

Finally in Section 4 we create four different data sets. Each of them included information for the characteristics of four stocks. Two bank stocks and two company stocks. We generalized our finding in these four data sets and compare the results between them based in graphical analysis.

**Table 3.1**  
**Summary Statistics for each of the four data sets<sup>a</sup>**

Order or trade characteristics		All observation						
			Mean	min	First quartile	median	Third quartile	max
<i>Panel A: order data set</i>								
<b>Limit price position</b>		3128	18.05	17.70	17.92	18.10	18.16	18.37
<b>Quantity</b>		3128	425.4	1.00	189.00	395.00	660.00	966.0
<b>Buy(%) (based on A1&amp;B1)</b>	<b>Limit price pos.</b>	2.46	18.35	18.34	18.34	18.34	18.35	18.37
	<b>Quantity</b>		419.00	1.00	189.00	355.00	661.00	662.00
<b>Sell(%) (based on A1&amp;B1)</b>	<b>Limit price pos.</b>	97.54	18.04	17.70	17.91	18.10	18.16	18.33
	<b>Quantity</b>		425.5	1.00	189.00	395.00	666.00	966.00
<i>Panel B: order packages data set (Total Ask/Total Bid)</i>		15640/15640	18.10/18.02	17.71/17.66	17.98/17.90	18.14/18.06	18.20/18.13	18.44/18.36
<b>Inside spread</b>		3128	0.01889	0.010	0.010	0.010	0.020	0.120
<i>Panel C: quotes data set (Total Ask-A1/Total Bid-B1)</i>		12512/12512	18.11/18.01	17.74/17.66	17.99/17.89	18.14/18.06	18.21/18.12	18.44/18.35

<sup>a</sup>For the trading day May 21, 2009, the first column reports the number of observation included in each category. The other columns report the descriptive statistics for the observations of each group. Trades at prices above the midquote are associated with buys (initiated by a buyer) and are given a value of 1. Trades below the midquote are called sells (initiated by a seller) and are given a value of -1. Inside spread is the differences between the first best ask and the first best bid.

**Table 3.2**  
**Summary Statistics for each quote<sup>a</sup>**

Order or trade characteristics	All observation						
		Mean	min	First quartile	median	Third quartile	Max
<b><i>B1</i></b>	3128	18.04	17.70	17.92	18.09	18.16	18.36
<b><i>A1</i></b>	3128	18.06	17.71	17.93	18.11	18.18	18.37
<b><i>B2</i></b>	3128	18.03	17.69	17.91	18.07	18.15	18.35
<b><i>A2</i></b>	3128	18.19	17.74	17.94	18.12	18.19	18.38
<b><i>B3</i></b>	3128	18.02	17.68	17.90	18.08	18.14	18.32
<b><i>A3</i></b>	3128	18.20	17.76	17.98	18.14	18.20	18.40
<b><i>B4</i></b>	3128	18.01	17.67	17.89	18.17	18.12	18.31
<b><i>A4</i></b>	3128	18.22	17.77	17.99	18.16	18.22	18.42
<b><i>B5</i></b>	3128	18.00	17.66	17.88	18.06	18.10	18.30
<b><i>A5</i></b>	3128	18.24	17.80	18.00	18.17	18.24	18.44

<sup>a</sup> Descriptive statistics for each quote of panel B.

### 3.3 Descriptive statistics about order book

Orders come into the book throughout the day at the time they are submitted to the market, and are removed from the book as they are executed, canceled, or expired. Using the quote data set, this section presents and discusses various descriptive statistics concerning the order book. Although our subsequent analyses are based on the five best quotes, it is important to remember that market participants only observe the first two best quotes.

#### 3.3.1 Relative spreads and depths in the order book

Table 3.3 reports the time series means and medians of relative spreads between adjacent quotes in the book, and depths at all levels for the stock in the sample. The spread is usually near to one tick in our sample. Based on Panel A, the mean (median) relative inside spread is 0.10463% which is high compared to other markets.

Volume is an important indicator in technical analysis as it is used to measure the worth of a market move. If the markets have made strong price move either up or down the perceived strength of that move depends on the volume for that period. The higher the volume during that price move the more significant the move. As we move from B5 (A5) to B1 (A1) the number of shares increases because stock reaches its strong and more profitable prices for traders.

In figure 1 presents the graph of relative spreads which is equal to  $2 \times (\text{difference between two quotes}) / (\text{sum of the same two quotes}) \times 100$  and the graph of relative inside spread  $[(\text{first best ask} - \text{first best bid}) / \text{quote midpoint}] \times 100$ . The quote midpoint is calculated as  $(\text{first best ask} + \text{first best bid}) / 2$ . As figure shows all the relative spreads are positive as the numerator of the fraction is always positive due to the referred relationship between quotes. The relative spreads of asks have bigger variance than the relative spreads of bids. Especially the relative spread of asks have many ups and down during all the period. On the other hand bids vary in the first half of the day and in the second are more flat. Finally the relative inside spread has only four ups which means that its variance is small. A small spread will exist when a market is being actively traded, and has high volume (number of contracts being traded). For many popular day trading markets, this is the case throughout the trading day, but for other markets, this only happens at certain

times of the day, such as the European open and the US open. A small spread is the type of spread that most day traders prefer, because it allows their orders to be filled at the prices that they want. Therefore, many day traders will temporarily stop trading if their market has a large spread.

### **3.3.2 Tick size and price discreteness**

The Athens Stock Exchange has one tick size of 0.1 euro which imposes price discreteness and forms a lower bound on the spread. The statistics on tick size on ASM are presented in Table 3.4. They are computed for all observation in our data set. We also create five samples classified by the mean of stock price during the sample period. We classify the sample using the measure  $0.1/\text{price}$  because the tick size is equal to 0.1 euro. The relative tick size is measured by  $0.1/\text{price}$  and the spread in ticks is equal to  $0.1 \times \text{observed spread}$  in the market. The prices of the stocks in our sample range from 17.64 to 18.71 euro implying a minimum relative spread (or relative tick size =  $0.1/\text{price}$ ) between 0.5345% and 0.5669%. The median relative tick size is 0.5513% which is relatively large compared to the median relative tick size for major capitalization in Europe. BATS (Pan-European Stock Market) Europe provides much information about tick size for all markets in Europe.

Theoretically a large tick size encourages limit orders traders to provide liquidity to the market, and imposes higher transaction costs on markets order traders. Given the price and time priority rules, the limit order trader has a first mover advantage only if the tick size is large enough to prevent quote matching. If the tick size is small, then the quote matcher obtains time precedence by submitting an order at a price slightly better than the standing quote.

**Table 3.3**  
**The relative spreads and depths in the data set<sup>a</sup>**

Panel A:The relative spreads between successive levels of the order(x100)										
Relative spread	A5-A4	A4-A3	A3-A2	A2-A1	A1-B1	B1-B2	B2-B3	B3-B4	B4-B5	
mean	0.1029219	0.09906699	0.0987535	0.0995634	0.1046308	0.06733564	0.06203653	0.0633558	0.0619554	
median	0.0555709	0.05580189	0.05572583	0.05572583	0.05613247	0.05557099	0.0554785	0.0555709	0.0555709	
Panel B:The average volumes at different levels of the order										
Depth	B5	B4	B3	B2	B1	A1	A2	A3	A4	A5
mean	2.218	2.122	2.636	3.113	6.873	5.632	2.668	2.061	1.591	1.384154
median	2.17	2.09	2.72	2.99	6.48	5.73	2.8	2.14	1.45	1.35
Panel C: Test of equality of spreads and depths across levels in the data set										
Hypothesis		Calculated			F-probability					
All relative spreads are equal		9.0221			0.01984					
All relative spreads excluding inside spread are equal		525.37			4.518e-07					
All depths are equal		0.3794			0.555					
All depths excluding the second best quotes are equal		0.5079			0.5028					

<sup>a</sup>Using the best bids and asks and their associated depths, this table reports the means and medians of the relative spreads between adjacent quotes and the quantities offered or demanded at these quotes. The reported depth is the original number of shares divided by 100. A and B denote ask and bid, respectively. B1 is the first best bid, and A1-B1 is the relative inside spread [(first best ask - first best bid)/Quote midpoint] times 100. The quote midpoint is calculated as (first best ask + first best bid)/2. Volume is the number of shares or contracts traded in a security or an entire market during a given period of time.

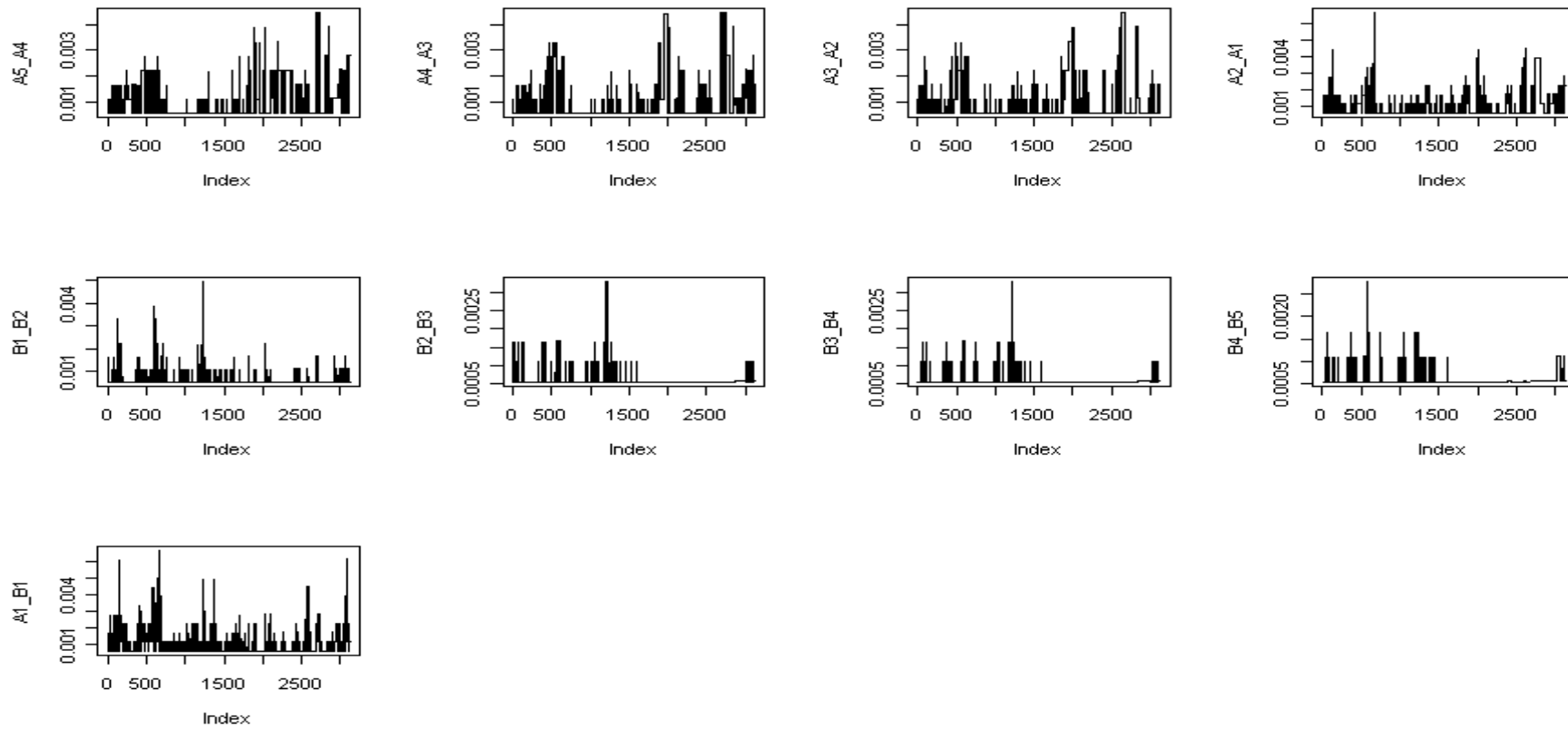


Fig.1. This figure presents the graphs of relative spreads and the graph of relative inside spread.



**Table 3.4**  
**Tick size statistics for the ASM<sup>a</sup>**  
**Variable**

	All stocks	Price level sub-samples				
		1(Lowest)	2	3	4	5(Highest)
<b>Number of quotes at all levels</b>	3128	17.70	17.95	18.09	18.17	18.37
<i>Quote midpoint range</i>	17.70 to 18.37	17.70 to 17.834	17.834 to 17.968	17.968 to 18.102	18.102 to 18.236	18.236 to 18.37
<i>Average quote midpoint</i>	18.035	17.77	17.92	18.035	18.17	18.3
<i>Inside spread that equal 1 tick (%)</i> ( 0.099-0.109)	0.19(6)	0.00	0.00	0.00	0.00	0.19
<i>Inside spread that equal 2 ticks (%)</i> ( 0.17-0.22)	1.8(57)	0.00	0.00	0.00	1.18	0.63
<i>Inside spread that equal 3 or more ticks(%)</i>	3.16(99)	0.57	0.70	0.57	0.79	0.51

<sup>a</sup>This table presents statistics on tick sizes on the ASM. The statistics are computed for all observations in the sample and for five sub-samples classified by the mean of stock price during the sample period. We classify the sample using 0.1/price because the tick is equal to 0.1euro for all stocks, which implies that the relative tick size can be measured by 0.1/price. Since the tick size is one, the spread (in ticks) is 0.1x observed spread in the market. The relative inside spread is (first best ask  $\pm$  first best bid)/quote midpoint. Quote midpoint.(first best ask+ first best bid)/2. The relative tick size is 0.1/quote midpoint. Limit order is the percentage of limit orders to the total number of orders.

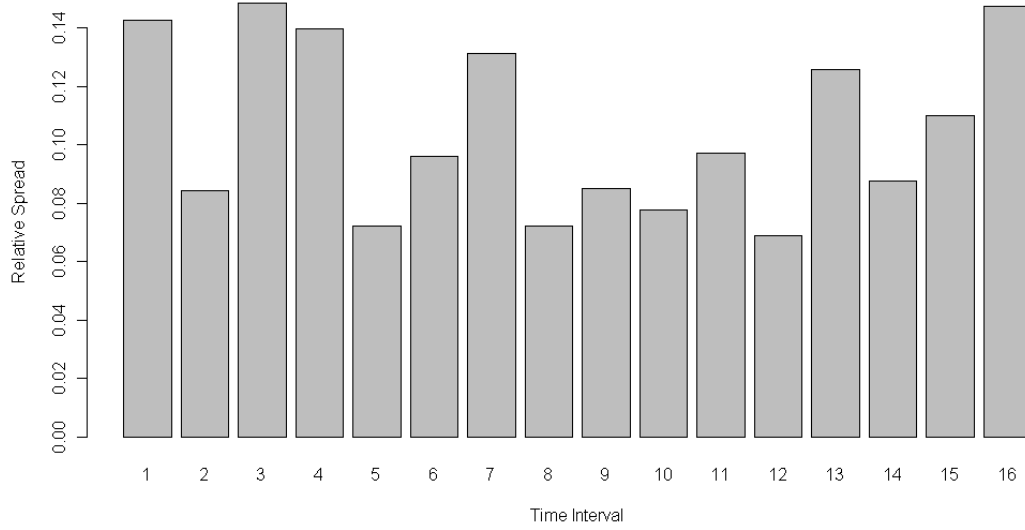
### 3.3.3 Availability of immediacy

Immediacy is available in the market when a market order can be instantaneously executed. In an order-driven market as the ASE, the availability of immediacy depends upon the limit orders are present. We can not denote when immediacy is unavailable at all levels of the book, as our data do not include information about limit orders.

### 3.3.4 Intraday patterns in the order book

In this section we examine the intraday patterns in the relative inside spread, depth and the squared quote midpoint return. As shown in figure 2 the first time interval has a high relative spread and the highest squared return. Both of measures have many increases and decreases. The high spread in the morning is due to greater uncertainty. As information asymmetries are partially resolved, traders become informed by observing the market. This leads to a decline in the spread during the day (after time interval 8 spread is more constant). We use the squared midpoint quote as a measure of stock return volatility. As shown in figure 2 and the regression,  $y = c + B_1D_1 + \dots + B_8D_8$ , results reported in Panel B of Table 3.5, volatility is at its highest during the first trading interval, followed by the last trading interval before the close. The test results for relative inside spread reported in Panel A of Table 3.5. The only difference in Table 3.5 is that the intraday relative spread is divided into eight intervals. During the day, the 6<sup>th</sup> trading interval has the lowest relative spread result (0.0829%). The regression is constructed so that the slopes represent the difference between the mean relative spread in this interval and the other intervals in the session. As constructed, the t-statistics are direct tests of whether any differences exist in mean relative spreads. Moving from the first to the 7<sup>th</sup> coefficient estimates one finds that both the difference and significance decrease until 5<sup>th</sup> coefficient and then they increase again. We also reject in the most of the differences the hypothesis that all differences are zero. The interval  $B_3 - B_6$  and  $B_5 - B_6$  are no significant patterns. In the second panel the most of the differences are no significant except for the two first.

(a) Intraday relative spread



(b) Intraday squared return(x100000)

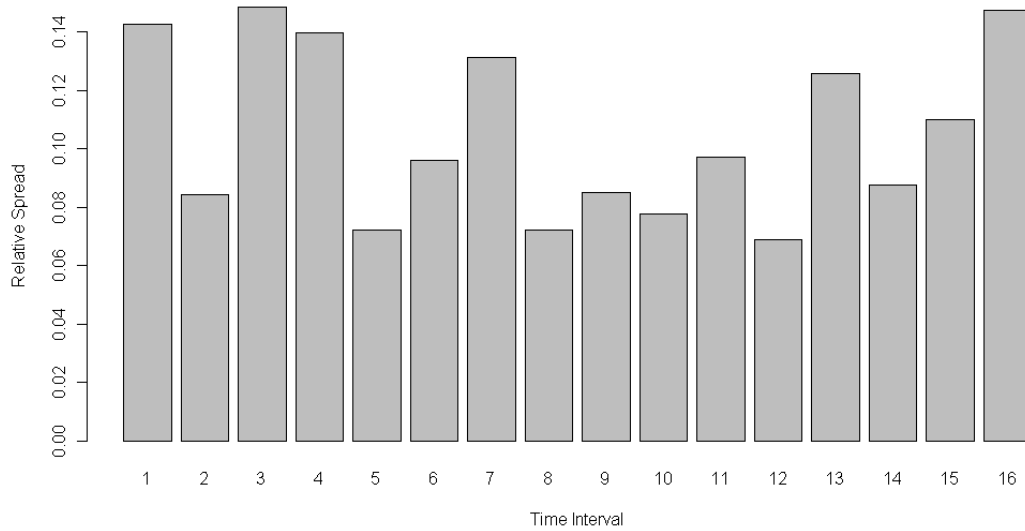


Fig.2. Intraday patterns in the order book. This figure reports the relative inside spreads and squared quote midpoint returns. Each trading session is divided into eight intervals, and the daily relative spread and squared midpoint return are computed for each interval for all stocks in the sample. The bars are the averages over the 65 days in the sample. The relative inside spread= $(\text{best ask}-\text{best bid})/\text{QMP}$  denotes quote midpoint= $(\text{best ask}+\text{best bid})/2$ . The quote midpoint return is calculated as  $\log(\text{QMP}_t)-\log(\text{QMP}_{t-1})$ .(a) Intraday relative spread. (b)Intraday squared return(x100000).

**Table 3.5**

**Tests for intraday patterns in the order book for the ASE<sup>a</sup>**

<i>Panel A: relative inside spread(x100)</i>		Interval	Coefficient	t-Statistic	P-value
No.of observation	3128				
Omitted interval	8	B <sub>6</sub>	0.0829316	21.423	< 2e-16 ***
F-statistic	32.09	B <sub>1</sub> – B <sub>6</sub>	0.0308243	5.630	1.96e-08 ***
P-value	< 2.2e-16	B <sub>2</sub> – B <sub>6</sub>	0.0642740	11.740	< 2e-16 ***
		B <sub>3</sub> – B <sub>6</sub>	0.0013984	0.255	0.798410
		B <sub>4</sub> – B <sub>6</sub>	0.0198942	3.634	0.000284 ***
		B <sub>5</sub> – B <sub>6</sub>	0.0001362	0.025	0.980153
		B <sub>7</sub> – B <sub>6</sub>	0.0249282	4.553	5.48e-06 ***
		B <sub>8</sub> – B <sub>6</sub>	0.0321382	5.870	4.80e-09 ***
<i>Panel B: squared quote midpoint return(x1000)</i>		Interval	Coefficient	t-Statistic	P-value
No.of observation	3127				

<b>Omitted interval</b>	8	$B_6$	8.147e-05	1.795	0.072756
<b>F-statistic</b>	6.16	$B_1 - B_6$	2.279e-04	3.553	0.000386 ***
<b>P-value</b>	3.554e-07	$B_2 - B_6$	3.456e-04	5.388	7.66e-08 ***
		$B_3 - B_6$	6.261e-05	0.976	0.329082
		$B_4 - B_6$	8.288e-05	1.292	0.196421
		$B_5 - B_6$	4.876e-05	0.760	0.447230
		$B_7 - B_6$	9.255e-05	1.443	0.149172
		$B_8 - B_6$	8.521e-05	1.328	0.184168

<sup>a</sup>This table reports the results from regressing relative spreads on a set of dummy variables. Trading session is divided into 8 intervals. The daily relative spreads are computed for each interval for all stocks in the sample. The regression equation takes the form  $y = c + B_1D_1 + \dots + B_8D_8$ , where Y denotes the relative inside spread during all intervals and days after all the observations are stacked; and  $D_i$ ,  $i=1, \dots, 8$ , is a dummy variable that equals one if the observation y belongs to interval i. To avoid linear dependency among the explanatory variables, only 7 of the 8 possible dummy variables are used in each regression. The dummy variable belonging to the interval with the lowest mean is deleted for this purpose. In this formulation, the constant term represents the coefficient of the deleted dummy variable, while the other coefficients represent the difference between each of the other intervals and the omitted interval. t-Statistics based on White covariance matrix estimation provide a direct test of whether any intraday differences exist between the omitted interval and the other intervals. F-statistics show the overall significance (all differences are zero). Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

## **Chapter 4**

### **An explanatory generalized analysis**

#### **4.1 A multi-day analysis**

In this section, we generalize our microstructure findings in data that includes information for four different stocks for more than one day. This chapter provides an exploratory analysis of new data sets for the price and the other quantities having regarded the time. In this analysis the time is not mentioned to the hours of a day but to six days. Our data includes information from the each stock for six consecutive days (26/11/2008- 03/12/2008). We compare the statistical findings of the intraday analysis with these in multi-day in order to analyze how these values change throughout the days. This data set is similar to the previous chapter. They include all the transactions from 10:35 a.m. to 5 p.m.. Due to a half pre-trading session and a half post-trading session, the transactions that investors did in these periods, are excluded. Also we excluded the transactions that they have zero quotes (bids and asks). For each order, the data set reports the time of creation, limit price position, quantity, turnover and the first five best ask and the first five best bid. Finally in the last Section of this chapter we compare the findings of these stocks and we report their differences and their similarities.

##### **4.1.1 National Bank of Greece**

National Bank of Greece S.A. (the Bank) is a Greece-based financial institution. It offers a range of integrated financial services, including corporate and investment banking, retail banking (including mortgage lending), leasing, stock brokerage, asset management and venture capital, insurance, real estate and consulting services. In addition, the Company is involved in various other businesses, including hotel and property management, real estate and information technology (IT) consulting.

In figure 3 observe an increase the first two days in the price of the stock and continuously moves down until the last day, where we have a decrease in the

decrement of the price. In the second plot in figure 3 we can see how the minimum and the maximum of price configure simultaneously. There are two differences. The minimum of the price has an abrupt increase in regard with the maximum. Finally between the fifth and the sixth day, notwithstanding the maximum of the price decreases, on the other hand the minimum of the price increases.

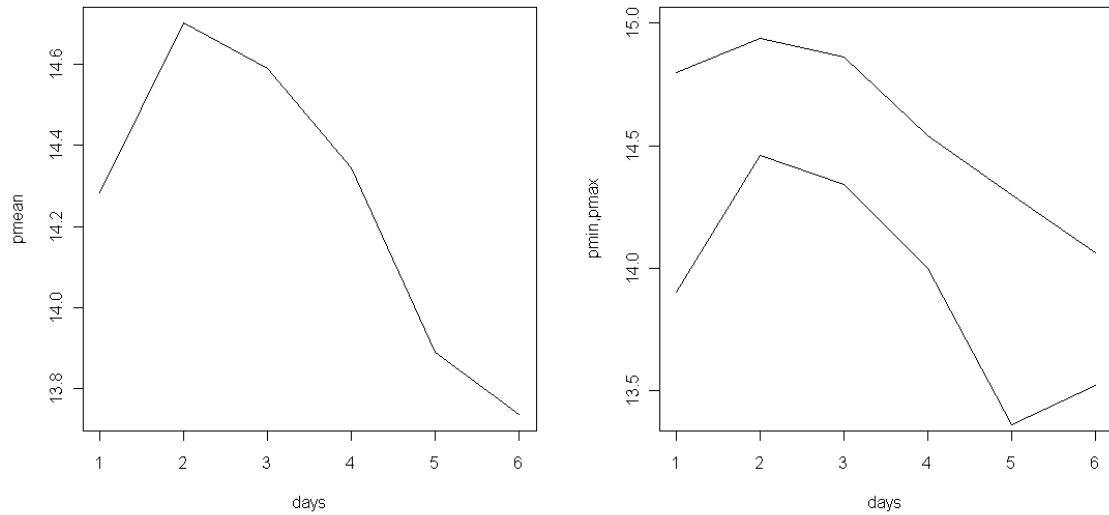


Fig. 3: the fluctuation of the mean price and the minimum/maximum mean price (ETE).

The figure 4 presents the prices pattern for each day. The patterns of the first (26/11), the second (27/11) and the fourth (01/12) day are similar. They do not have sharply fluctuation and on November 27<sup>th</sup> there is an increase in prices as the plot is top-displaced. On the other hand the fourth day there is a slight decrease in the price level. The last two days (2/12 & 3/12) has a similar pattern but different from the other days. They also show upward progress of prices and on December 2<sup>nd</sup> there is sharply fluctuation. The third day has a different pattern from the other days. It is similar with a U-shaped pattern.

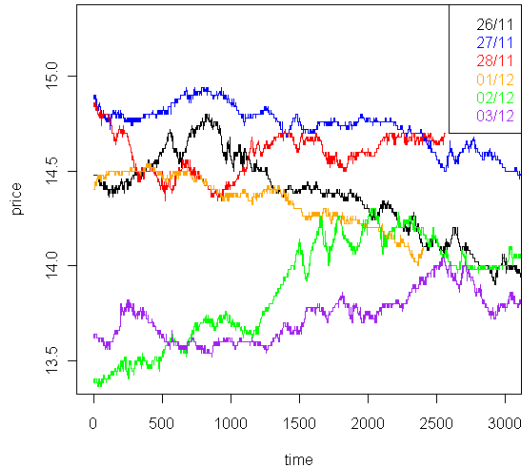


Fig.4: multi-day prices pattern (ETE)

The plots of the first best ask and first best bid reported in figure 5. The first best quotes have similar ups and downs with the plots of the price because they are the bid and offer prices before a transaction occurs. The only difference is that in the first day there is a small outlier (min first best ask=10.42€).

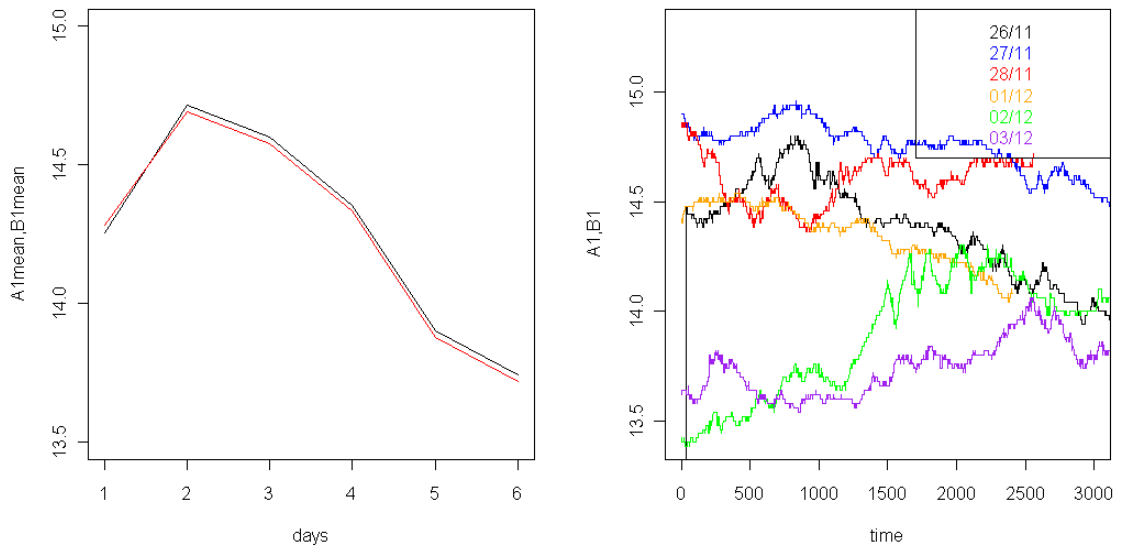


Fig. 5: first best quotes pattern (ETE)

Figure 6 compares the relative inside spreads for each day. The spreads on December 2<sup>nd</sup> have big dispersion and also have many outliers. The spreads of first day also have two big fluctuations. Usually the big variation of the spreads depends



on the difference between the demand (ask price) and the interest (bid price) in a stock and on the total trading activity of the stock. Most of the days have small spreads. This means that the stock is being actively traded, and has high volume (number of contracts being traded). Some spreads during the fourth day are large because the stock is not actively traded and has low volume. A small spread is the type of spread that most day traders prefer, because it allows their orders to be filled at the prices that they want. Therefore, many day traders will temporarily stop trading if their market has a large spread.

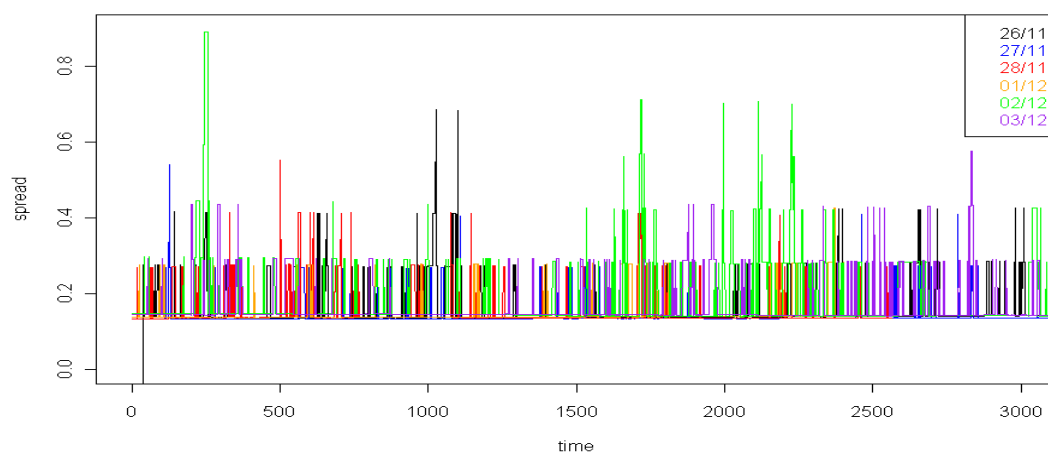


Fig. 6: This figure reports the relative inside spreads during the six days (ETE)

#### 4.1.2 Alpha Bank

Alpha Bank A.E. (the Bank) is a banking and financial services company in Greece, offering a range of services, including retail, small and medium-sized enterprise (SME) and corporate banking, credit cards, asset management, investment banking, private banking, brokerage, leasing and factoring. The Company offers corporate and retail banking, financial services, investment banking and brokerage services, insurance services, real estate management and hotel activities. It operates under the brand name of ALPHA BANK. The Bank has six business segments: Retail Banking, Corporate Banking, Asset Management and Insurance, Investment Banking and Treasury, South Eastern Europe, and Other.

The fluctuation of the price reported in figure 7. The first plot shows the price of the stock varies during the six days. We observe a small increase between the first and

the second day, a significant decrease the third day and the same pattern the next three days with a decrement on the tension of moving ups and downs. In the second graph in figure 7 we can see how the minimum and the maximum of price configure simultaneously. The two lines have almost the same fluctuation and common progress with the mean price. The stock of Alpha Bank has smaller mean price than National Bank of Greece and it differs in price pattern.

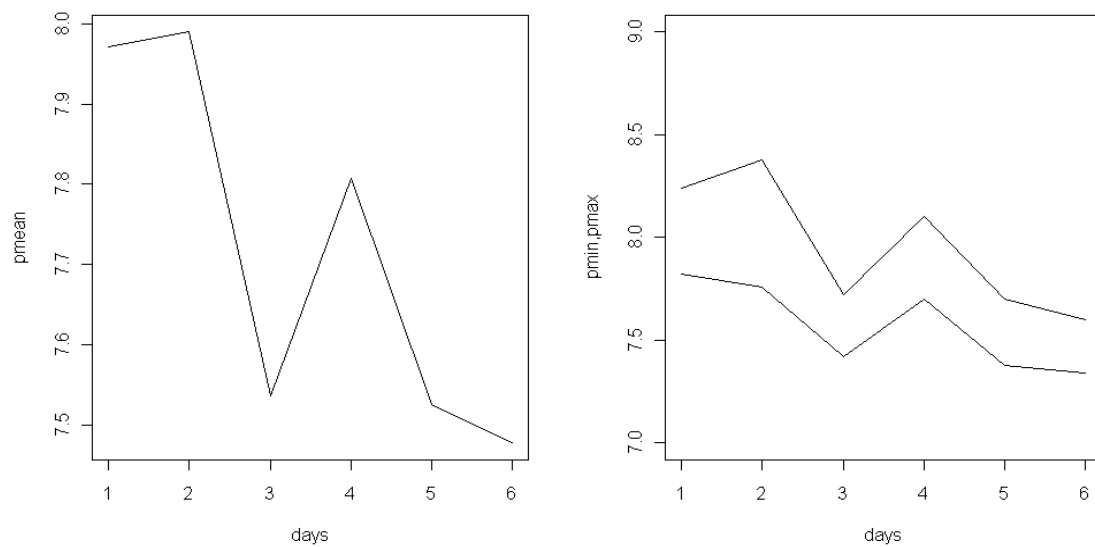


Fig. 7: the fluctuation of the mean price and the minimum/maximum mean price (ALFA).

The figure 8 presents the prices pattern for each day. All the days have similar fluctuations. There are not such big differences as in National Bank. The first (26/11), the second (27/11) and the fourth (01/12) day have a small downward progress in price and a small increase in begin of the time. The rest days have also common progress and almost constant price. The multi-day prices pattern of Alpha Bank has many differences with this of National Bank.

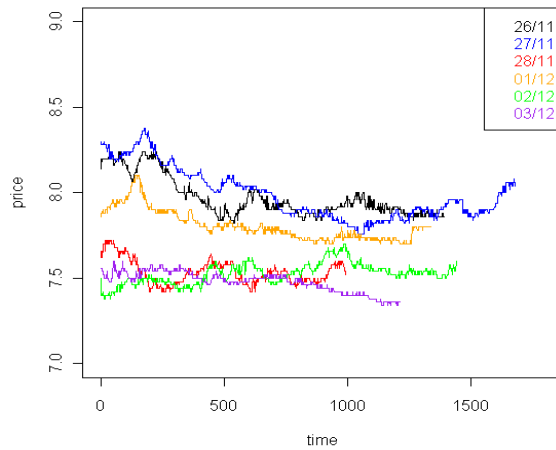


Fig.8: multi-day prices pattern (ALFA)

The plots of the first best ask and first best bid reported in figure 9. As we referred in Section of National Bank this figure is almost the same with the previous.

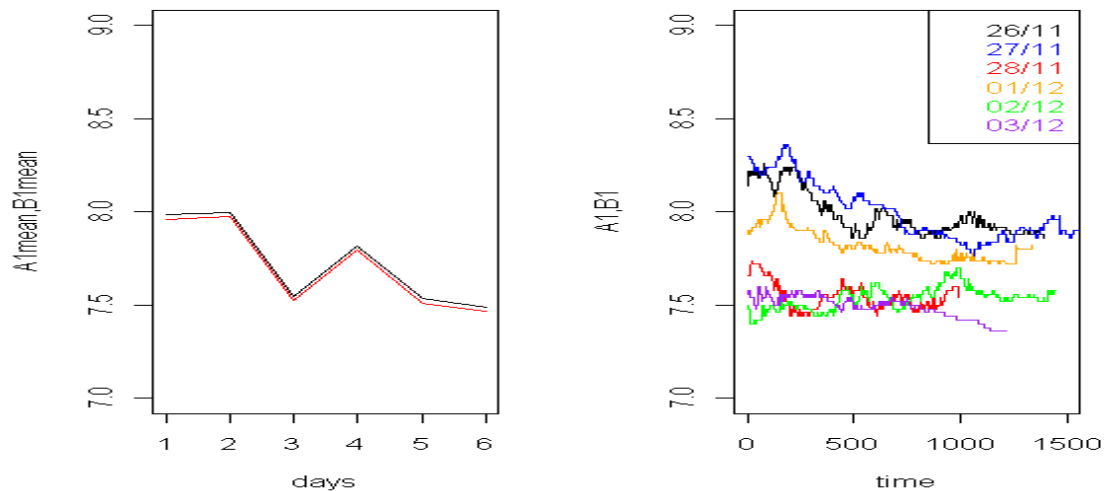


Fig. 9: first best quotes pattern (ALFA)

The last figure of this Section presented the relative inside spread of each day. As shown in figure 10 the spreads on December 2<sup>nd</sup> have big dispersion and also have many outliers. This is also observed in the same plot of National Bank. The spreads of first day also have many big fluctuations. The present of ups and downs is due to the difference between the ask price and bid price and on the total trading activity of the stock. Most of the days have small spreads.

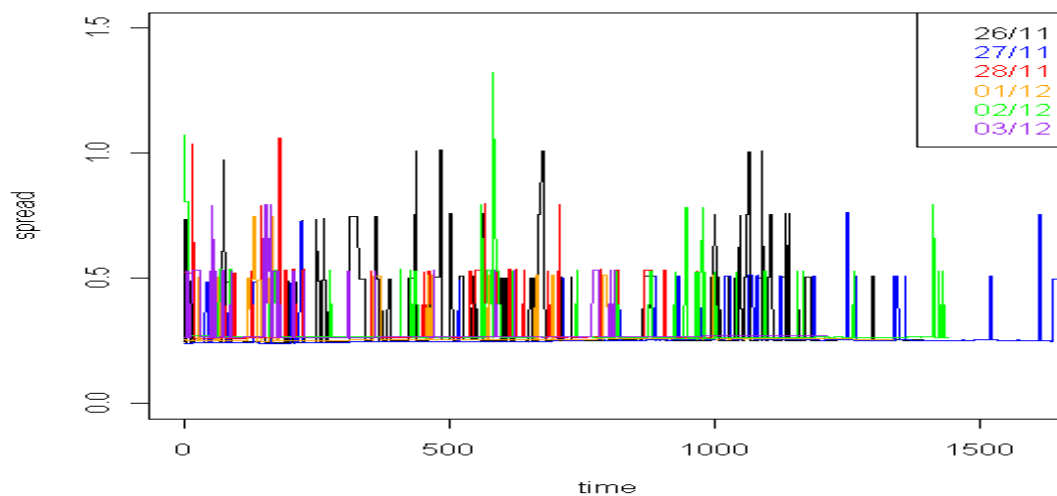


Fig. 10: This figure reports the relative inside spreads during the six days (ALFA)

#### 4.1.3 Public Power Corporation S.A.

Public Power Corporation SA (DEH) is a Greek industrial and commercial enterprise active in the energy sector. The Company is engaged in the construction, operation and maintenance of electricity plants, as well as the generation of electric power through lignite, oil, hydroelectric and natural gas stations, and renewable sources of energy. It also has a fully owned power transportation and distribution system. Public Power Corporation SA is also active in the telecommunications sector via its subsidiary PPC Telecommunications SA. As of December 31, 2008, the Company operated through 12 wholly owned subsidiaries.

In figure 11 we observe that the price of this stock have similar fluctuation with the price of Alpha Bank .But this figure reports for first time in this Chapter a continuous increase of price. This can also be observed in figure 12 The prices pattern in this figure shows an upward tendency of prices but each day have a different pattern. The plots of the first best ask and first best bid reported in figure 13. This plot is similar with the previous. In prices graph is also presented a small decrease in this increase progress. Figure 14 compares the relative inside spreads for each day. The spreads on November, 26 have different dispersion from the other days and some outliers. Some spreads during the fourth day are large because the stock is not actively traded and has low volume. As shown the characteristics of this stock change during the time with

another pattern of the two previous stocks. This happens because Public Power Corporation does not have the same kind of traders as the banks.

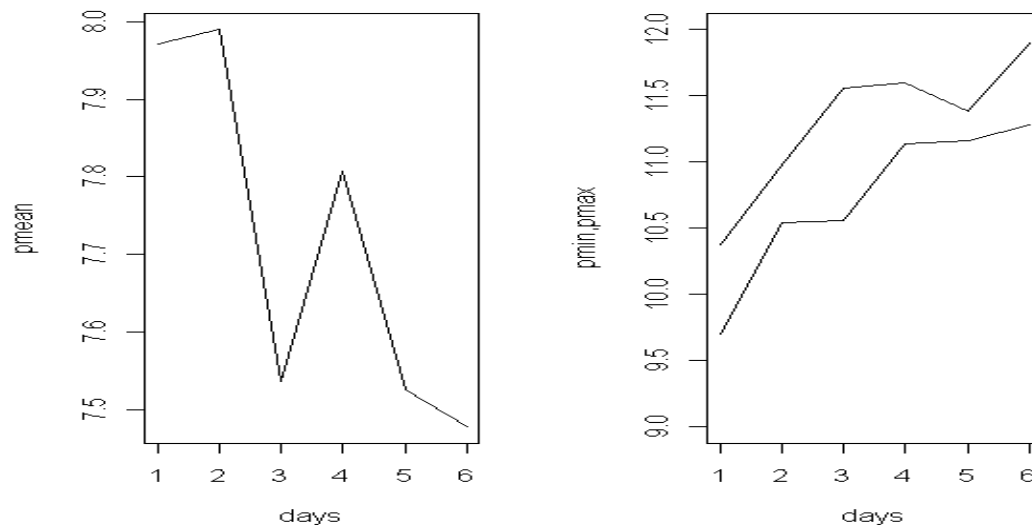


Fig. 11: the fluctuation of the mean price and the minimum/maximum mean price (DEH).

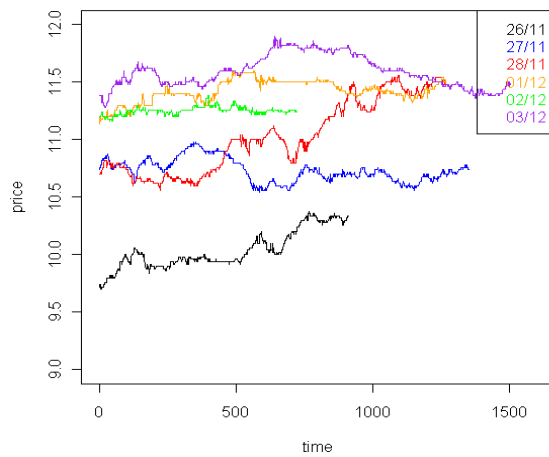


Fig.12 multi-day prices pattern (DEH).

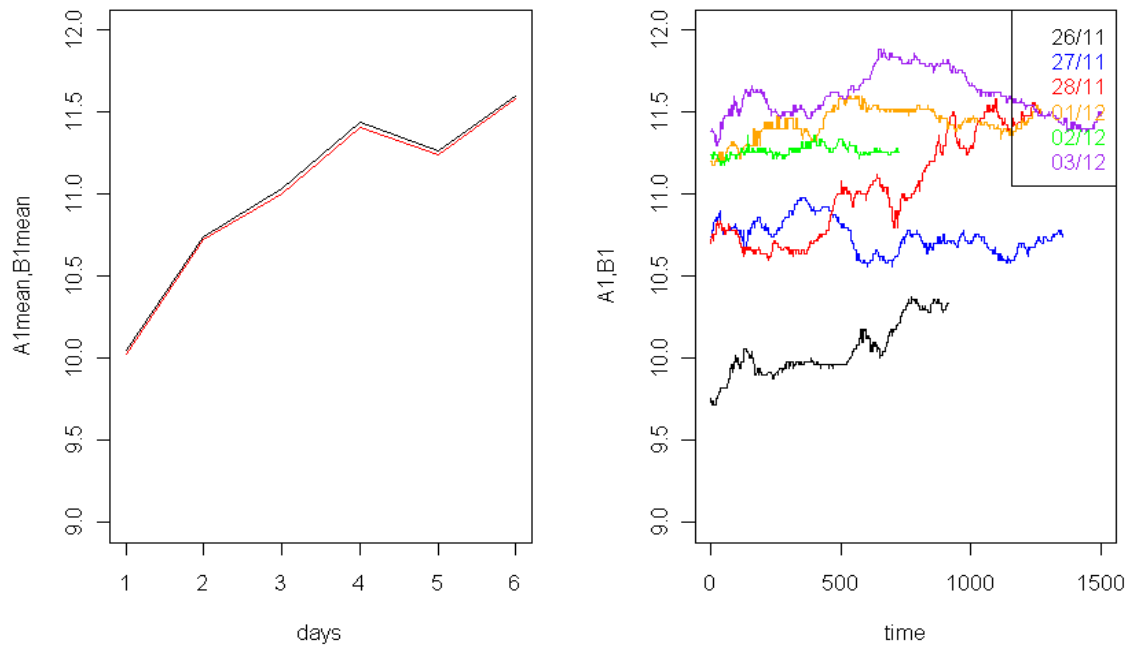


Fig.13: first best quotes pattern (DEH)

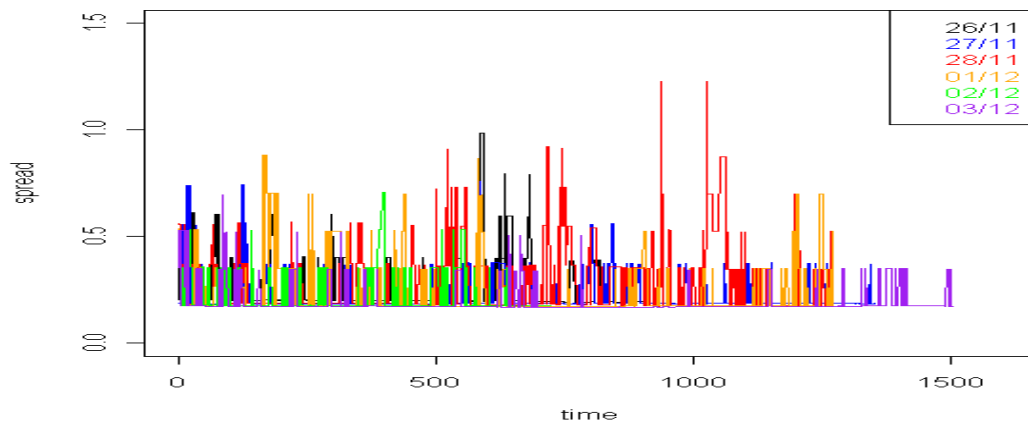


Fig. 14: This figure reports the relative inside spreads during the six days (DEH)

#### 4.1.4 Hellenic Telecommunications Organization

Hellenic Telecommunications Organization S.A. (OTE) is a provider of telecommunications and related services. The Company provides long-distance and international fixed-line voice telephony and Internet access services in Greece. OTE,

along with its subsidiaries, offers a range of products and services, including broadband services, fixed and mobile telephony, satellite, high-speed data communications and leased line services.

In figure 15 we observe an increase the first two days in the price of the stock and continuously a dig decrease. The pattern of the first days is repeated the next days with different tendency. The third day there is a upward increase and a proportional decrease the next day. In the second plot in figure 15 presented how the minimum and the maximum of price configure simultaneously. There are two differences. The minimum of the price has an abrupt decrease in regard with the maximum. Finally between the fourth and the fifth day, notwithstanding the maximum of the price decreases, on the other hand the minimum of the price increases.

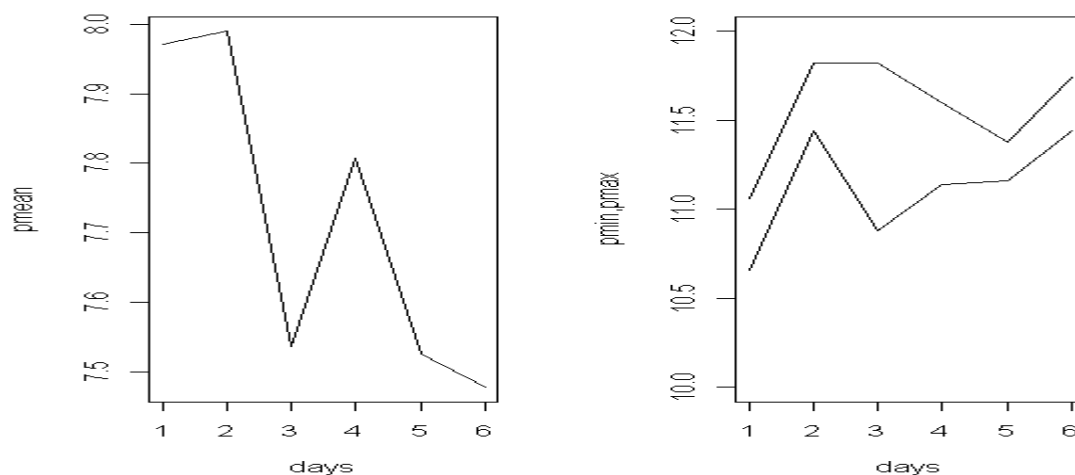


Fig. 15: the fluctuation of the mean price and the minimum/maximum mean price (OTE).

The figure 16 presents the prices pattern for each day. There is very different pattern and specially the third day (28/12) have sharply fluctuation. The half part of the graph moves in a bigger level of price and it seems that the next days have also moved again in lower level than the first. On the other hand the fourth day the others days have constant ups and downs with nothing special to mentioned

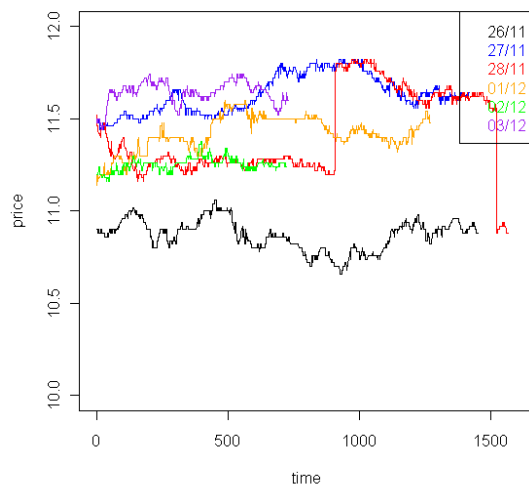


Fig.16: multi-day prices pattern (OTE).

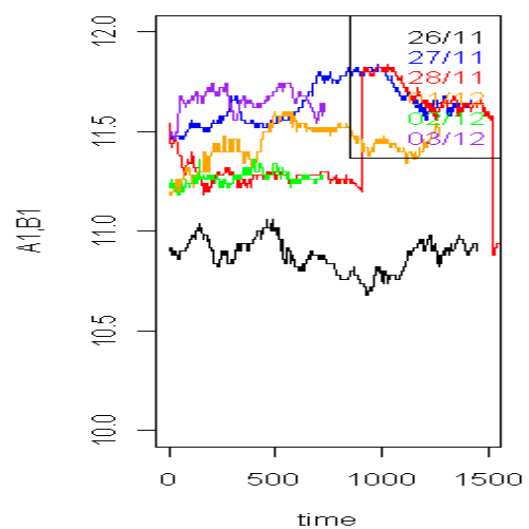
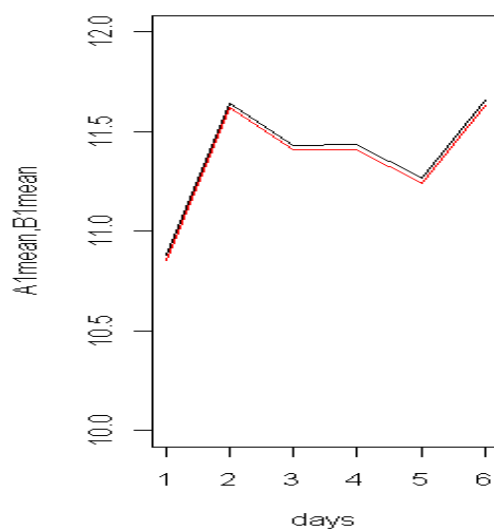


Fig. 17: first best quotes pattern (OTE)

Figure 17 compares the relative inside spreads for each day. The spreads on December 1<sup>st</sup> have big dispersion and also have many outliers. All the days have many ups and down during the first half of the day. This means that in this period the market is not being actively traded, and has low volume (number of contracts being traded). But at the second half of the day the spreads are small. The traders have the chance their orders be filled at the price that they want.



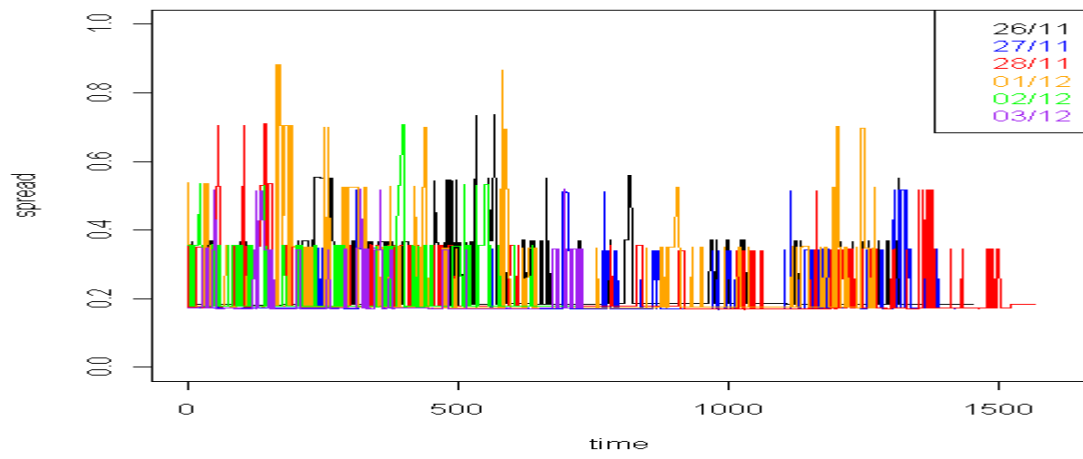


Fig. 18: This figure reports the relative inside spreads during the six days (OTE)

## Chapter 5

### Conclusions

In this diplomatic thesis we present a big review of the most recent researches used limit order book or TAQ database in their models. We create ten big categorizes of these papers in order to help the reader understand what they examine. Decided that the most interesting work for this thesis is the published paper of Mohammad Al-Suhaibani and Lawrence Kryzanowski, we describe and analyze the microstructure of the ASE under the Integrated Automatic Electronic Trading System (OASIS).

We analyze the order book using many rich data sets on orders, limit price position, quantities of orders, quotes and transactions. The intraday patterns of ASE are surprisingly similar to those found in other markets with different structures. These include U-shaped patterns in traded volume, number of transactions and volatility.

We find that the relative inside spread is higher at the open and at the close on the ASE. We find that the average relative inside spread is large compared to other markets, mainly due to a relatively high tick size. Tick size is an important determinant of the inside spread for low priced stocks, and for all other relative spreads. Also the relative spreads between the bids is higher only at the open and declines gradually afterwards.

We find that there is a big variation in the weekly analysis due to the difference between the ask and the bid price. This thesis investigates the bid-ask behavior of the Athens order-driven stock market and we analyze high frequency transaction data from November 26, 2008 to December 3, 2008.

Finally we provide a glossary in order to clear up many financial terms reading the dissertation and the computation of the models was in matlab and in R.

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