FACTORS CAUSING THE PRESENCE OF ASYMMETRICAL INFORMATION IN EASDAQ

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ABSTRACT

The growing process of globalisation in Financial Markets over recent years has been brought about mainly by technological advances, changes in regulating systems and the need to adjust to the expectations of new investors whose behaviour patterns have changed significantly in the past decade. This process certainly contributes to a more accessible and homogeneous economic and financial environment. Nevertheless, market globalisation does not guarantee the same access conditions for all investors. Even though they are now better informed, access to sources of private information by a small number of investors and their use of this information for their own benefit demonstrates the existence of so-called "Insider Trading". Insiders are people who abuse their dominant position in the market by negotiating -directly or indirectly- with inside information, by spreading false or deceitful rumours or by indulging in activities aimed at manipulating either market operations or market evolution. In this context, the present study analyses the problems arising from the existence of information asymmetries in Technological Stock Markets and, specifically, in the EASDAQ Market (European Association of Securities Dealers Automated Quotations) given its proximity to the Spanish financial environment within the European Union framework and its special characteristics as a newly created market.

Key words: Insider Trading, Spread, EASDAQ.

1. INTRODUCTION

Accepting theory that the market is not perfect, Financial Economics has incorporated the component information asymmetries into its analyses by studying the effects of opportunistic actions, which cause moral hazard, adverse selection and/or signalling[1]. Empirical studies evidence the interest of researchers in defining and agreeing on what *insiders* are by profiling their behaviour and measuring their abnormal profits against pre-established patterns. In essence, the intention is to assess the efficiency or inefficiency of the market in adequately assimilating and transmitting inside information[2]. This requires profound knowledge of market agents, trading systems and regulating policies. It is necessary to track the publicly available information in the market at all times, studying the events that tend to have an impact on price formation. However, there is another approach to study the existence of asymmetries, based on the defensive policies brought into play by intermediaries when faced with better-informed investors. This leads us to reconsider aspects such as the origin and nature of the information asymmetries in stocks markets. Knowing where it is to be found, who and how it is generated are basic questions that must be answered in order to find possible models for determining and measuring the existence of information asymmetries. The study of the financial environment at the firm (internal control mechanisms) and market level (efficiency level) must be combined with both individual investment activity and the cost of the transaction opportunity (with or without inside information).

To adequately consider the empirical work carried out in breaking-down the bid-ask spread[3] (in which the adverse selection component is particularly relevant), it is necessary to go back to the problem of information, beginning with the trading risks taken by market-makers. Market makers who know the stock exchange activities in depth adopt strategic intervention positions and cover their operations by introducing variations in the prices for deals they quote. These specialists have all the public information available in real time and are able to analyse and predict the behaviour of the market over a short term in the absence of inside information. As it is impossible to set limits to the activities of inside traders, they adjust their speculative margins in order to mitigate the risks arising from their abuse of dominant position in the market and guarantee profitability for their operations.

The fundamental aim of this study is implementation of a model for analysis that determines the existence of information asymmetries in the technological Stocks Market and its effect on spreads as based on the variations observed in the stock quoted. In order to achieve this objective 18 variables were defined that sum up the stock behaviour of the population under study. Over 80,000 entries were analysed by means of techniques involving stratified sample selection, multivariate analysis, descriptive statistics and inferential statistics, which allowed development of a specific methodology and the implementation of a System for Determining the Homogeneity of Information Asymmetries.

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1 Among the first researchers on information economics we find studies on market analysis and information asymmetries by George Akerlof (1970) Nobel Prize of Economics 2001, together with Michael Spence and Joseph Stiglitz.

2 See Fama (1970), Rubinstein (1975), Grossman and Stiglitz (1980), Brealey and Myers (1999).

3 Copeland and Galay (1983), Glosten and Milgrom (1985), Easley and O'Hara (1988), Glosten and Harris (1988), Rubio and Tapia (1996), Acosta et al. (2000).

EASDAQ has been a branch of the Nasdaq Stock Market, a market in which American researchers, pioneers of information economics, have successfully tried their theories on spread. In spite of the modifications introduced from the operational and transactional point of view as a consequence of the new stockholders and the new name, business is still chiefly handled by market makers. The hybrid nature of this market and its Pan European positioning confer on it a different character from the various domestic technological stock markets based in Europe. From the point of view of researchers, this market has had the advantage of being a newly created market combining traditional regulations found in European markets with the innovative supervision strategies applied in the NASD family of markets together with the special feature of multi-currency trading, the latter which is uncommon in other markets.

At this especially interesting moment in the European Union, when supervising policies are being assimilated and revised to afford markets transparency and integrity, it is necessary to assess the efficiency of technological markets and specify the possible strategies that diminish the risks of the abuse of dominant positions in the market as specified in the new regulations. The European stock markets must compete on an equal basis with their American and Asian counterparts. Control techniques must not interfere in market flexibility and liquidity; instead, they must be the economical agents' guarantee. Therefore, it is necessary to introduce and improve general assessment techniques, including technological advances, to the study of abnormal earnings. Only in this way will the conception of a single stock market within the European Union framework be possible.

2. BACKGROUND

Except for the supervising and control activities carried out by the administration and responsible institutions, there is no history on the study of information asymmetries on EASDAQ (Nasdaq Europe). This is not extraordinary, as this market is relatively very recent (1996). Besides, the more relevant empirical studies on market prices have focused on American markets[4]. Research studies conducted on price formation on Nasdaq Stock market and Amex[5] are of particular interest. These two markets belong to the NASD family, as does Nasdaq Europe. Thus, the behaviour observed in the parent company, (Nasdaq Stock Market) may act as an indicator applicable, in relative terms, to the subsidiary companies[6]. From this perspective, the objective is analysis of the European market independently of the current main stockholder, even if the European market does show a number of similar characteristics, including those relating to the initial contract and settlement systems which have permitted, from its beginning, dealings in stocks officially traded in international markets like the Nasdaq through the so-called Traded Segment.

[4] See Acosta et al. (1999).

[5] See: Stoll (1989); George, Kaul and Nimalendran (1991); Affleck-Graves, Hedge and Miller (1994), Huang and Stoll (1997).

[6] Shared supervisory and control policies currently define the "Nasdaq Markets", with the limitations arising from the legislative framework to which they are linked by reason of their registered headquarters. In this way, analysis of the Nasdaq Europe market would round out work done on the Nasdaq Stock Market. However the expectations of this study go further than that, especially as the period chosen for testing for the presence of asymmetry in information is prior to the acquisition of 58% of the share capital of EASDAQ by Nasdaq.

The effects of information asymmetries on price spread have been tested successfully, from different starting hypotheses, although the majority follow the same pattern derived from the model presented by Huang and Stoll in 1997. The study of this model and the existing literature on the determining factors of abnormal earnings have been fundamental in developing this research project, which sprang from the importance of the role of abuse of dominance positions in European and international markets. This information problem has acquired unprecedented importance as the stock market became the market for not only the specialized investors but also for those who dealt with time deposits, fixed interest stocks and National Treasury bonds. The implementation of new bank products linked to stock market quotations and the increase in the offer of capital investment funds evidence the change in the financial investment consumers' behaviour in the last years.

The contribution of the present paper lies in offering an analytic tool to observe whether the market's behaviour is in tune with the expectations of the agents taking part in it or, on the contrary, whether the risks of the existence of information asymmetries is having a negative impact on price formation and investors' profitability.

3. SYSTEM FOR THE DETECTION OF INFORMATION ASYMMETRIES

3.1. Objectives of the Study

The aim of this study is to detect the existence of information asymmetries affecting the stocks traded in the European Technological Market EASDAQ. To achieve this aim, a detailed follow-up of this market, from its origin in 1996 up to the first quarter of 2002, was performed. This was possible thanks to the exchange information specifically made available by EASDAQ to allow the completion of this project. The changes which took place over this period were numerous and varied, and were conditioned by the new global context of stock markets specializing in the research and new technologies business segment. The difficulties faced by this sector at global level, especially since the start of 2000, have brought some firms to situations of extreme indebtedness, causing mergers, filings for protection from creditors and even bankruptcies. Hence, corporate actions carried out by technology firms at global level both before and after the beginning of the slow-down were considered.

3.2. Sources of Information

In undertaking this study, the EASDAQ database was used, which includes data relating to market operations carried out from the beginning of this exchange market in 1996 up to September 2000. In particular, it was possible to access average closing prices and the volumes traded daily in this market for the segment comprising stocks officially registered (*Listed Segment*). The database also includes the spreads indicated by market makers for both this segment and for the segment involving stocks traded without an official quote (*Traded Segment*) for the period running from 1 January 1999 to 30 June 2000, and the EASI index from 1996 to September 2000. Similarly, the necessary means were used to incorporate the information publicly available on EASDAQ market (*Nasdaq Europe*), related to applicable regulations, member firms, issuing companies, trading and settlement systems, quoted prices, trading volumes and execution prices (maximum, minimum, opening and closing for each trading session), as published in bulletins and official lists, before and after 8 June 2001, so as to assess any changes occurring as the result of the new pattern of stockholders in this market.

3.3. Variables used

Based on the information given in the market's official publications and the EASDAQ database, the variables described below were used for this study:

1. ***Firm***.- A numerical code indicating the company issuing a given stock or the traded stock itself.
2. ***Date*.-** The date of the trading session. This variable sets differing periods of analysis (day, week, fortnight, month, three-month period and so forth) for checking the asymmetry hypothesis.
3. ***Time*.-** An electronic recording indicating the point in time at which an official market maker enters prices and order volumes given by investors.
4. ***Opening Price*.-** The price at which a given stock stands at the beginning of a trading session.
5. ***High*.-** The maximum price reached in dealings for a given stock during a market session.
6. ***Low* .-** The minimum price reached in dealings for a given stock during a market session.
7. ***Last Price*.-** The price at which a given stock is last traded during a stock market session.
8. ***Volume*.-** The number of shares traded during a stock market session.
9. ***Currency*.-** The currency in which a given stock is quoted, with which it was officially registered during the process of admission to trading.
10. ***Segment*.-** This variable indicates the type of issue, whether quoted or traded.
11. ***Best Bid Price*.-** The highest price recorded as offered by market makers for a given stock. From the point of view of investors, it is the best price they can get for their shares.
12. ***Best Bid Size*.-** The number of shares that official market makers acquire at the "best bid price".
13. ***Best Offer Price*.-** The lowest price recorded as quoted by market makers when dealing in a given stock. From the point of view of investors, it is the best price at which they can purchase holdings in a specific issue.
14. ***Best Offer Size*.-** The total number of shares offered at the "best offer price" by official market makers.
15. ***Mid Price*.-** This is the average of the best offer price and the best bid price, quoted at the end of the trading session by a market maker.
16. ***Change of Mid Price*.-** This is the percentage by which mid prices varies from one consecutive trading session to the next.
17. ***Spread*.-** This is the difference between the best offer price and the best bid price, as quoted at a given point in time by a market maker.
18. ***Spread_p*.-** The percentage difference between the best offer price and the best bid price quoted by a market maker.

Some of the above mentioned variables have been used to classify the population studied. Namely, the variables: *Date*, *Segment* and *Currency* allowed stratification of the overall set of data available. Other variables, relating to prices and volume traded, were used in combination to classify stocks issues by means of sophisticated multivariate analysis techniques. In the end, the choice of variables was made on the basis of rational selection criteria, in an attempt to eliminate redundant information and to sum up relevant data adequately, so as to construct a model for determining the existence of information asymmetries in accordance with the reality of the EASDAQ Market.

Although reliable sources were used, it was necessary to undertake a preliminary process of data cleaning of the stocks studied for the variables selected as recording errors typical of mass data compilation were detected which could have distorted results. Likewise, in order to set limits to the study, all of the stocks analysed belonged to the Listed Segment of EASDAQ[7], continuously traded in that market, from 1 April 2000 to 30 June 2000. On 14 March 2000 the EASI index reached its historical maximum (2,539.38 points). From that date onwards, the market went into a recession phase that significantly worsened over the second half of 2000 and continues at present. For this reason, the second quarter of the accounting year 2000 is particularly interesting, since it marks the beginning of the decline while continuing the high level of trade that was reached in the first quarter of 2000. Other periods could be analysed in further studies. **Table 1** shows the entries analysed, corresponding to the second quarter of 2000. As can be seen, the figures eliminated for this period amount to around 2% of the total. This figure can be deemed immaterial for the purposes of the study.

Table 1: Entries analysed, 2nd quarter of 2002

Month	*Description*	*Number of entries*
April	*Entries not reviewed*	**28,182**
	Listed entries reviewed	**17,594**
	Traded entries reviewed	**10,044**
	Total entries reviewed	**27,638**
	Entries eliminated	**544**
	Percentage of entries eliminated	**1.93%**
May	*Entries not reviewed*	**28,684**
	Listed entries reviewed	**18,933**
	Traded entries reviewed	**9,172**
	Total entries reviewed	**28,105**
	Entries eliminated	**579**
	Percentage of entries eliminated	**2.02%**
June	*Entries not reviewed*	**24,895**
	Listed entries reviewed	**16,060**
	Traded entries reviewed	**8,374**
	Total entries reviewed	**24,434**
	Entries eliminated	**461**
	Percentage of entries eliminated	**1.85%**
Total	*Entries not reviewed*	**81,761**
	Listed entries reviewed	**52,587**
	Traded entries reviewed	**27,590**
	Total entries reviewed	**80,177**
	Entries eliminated	**1,584**
	Percentage of entries eliminated	**1.94%**

SOURCE: Original compilation by authors

[7] Stocks "traded" on EASDAQ will not be included in the study, as these stocks are registered and quoted in other markets where their main business takes place. Therefore they have little or nothing to do with achieving the aims described here.

3.4. Methodology

The empirical analysis was based on observation and trials from market makers buying and selling prices and volumes. It is possible to study the problem from several perspectives, as follows:

i) By choosing the individuals who by their nature could be considered potential insiders and analysing any "abnormal" earnings they achieve.

ii) By breaking down the spread, taking into consideration operational costs, portfolio holding expenses and adverse selection costs taken on by market makers.

iii) By analysing the overall behaviour of prices and size traded, so as to determine whether there is homogeneity or heterogeneity in the formation of spreads relating to the stocks traded.

Independently of the type of market considered, there is a certain tendency on the part of investors to “imitate” “supposedly suspicious" operations. Furthermore, casual or indirect access to inside information is impossible to detect beforehand. Therefore, the choice of potential risk groups was limited to assessment of the effects of asymmetry generated by insiders directly linked to the firm, the market or supervising and control bodies (business executives, auditors, supervisors, inspectors…).

From this perspective, the results obtained by researchers taking option (i) allow acceptance or rejection of the market efficiency hypothesis in its various forms (strong, semi-strong, weak), but is useless for quantifying the distortion caused in price formation by the presence of better-informed investors. This problem can be overcome by those who chose option (ii) and who are interested in analysing the effects of information asymmetries on the bid-ask spread according to the approach taken by Huang and Stoll (1997)[8]. The models developed within this framework allow assessment of the magnitude of the adverse selection component in the spread as introduced by market makers in order to compensate for the implicit risk of asymmetry they undertake. In particular, when applying Huang and Stoll’s model[9] to the representative segment of EASDAQ stock traded in the second semester 2000, the adverse selection component represents 20% of the spread.

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[8] See HUANG, R.D. and STOLL, H. (1997): “The Components of the Bid-Ask Spread: A General Approach”, *The Review of Financial Studies*, 10(4), Winter, pp. 995-1034.

[9] These authors propose a generic model that tries to sum up prior studies: Ho and Stoll (1981), Copeland and Galay (1983), Roll (1984), Glosten and Milgrom (1985), Choi, Salandro and Shastri (1988), Glosten and Harris (1988), Stoll (1989), George, Kaul and Nimalendran (1991), ...

Huang and Stoll develop a simple model of transaction prices, quotes, and the spread within which other models are reconciled. They adopt the convention that the time subscript “t” encompasses three separate and sequential events. The unobservable fundamental value of the stock in the absence of transaction costs “V_t”, is determined just prior to the posting of the bid and ask quotes at time “t”. The quote midpoint, “M_t”, is calculated from the bid-ask quotes that prevail just before a transaction. They denote the price of the transaction at time “t” as “P_t”. Also define “Q_t” to be the buy-sell trade indicator variable for the transaction price, “P_t”. They model the unobservable “V_t” as follows:

$$V_t = V_{t-1} + \alpha\, S/2\, Q_{t-1} + \varepsilon_t$$

where “S” is the constant spread, “α” is the percentage of the half-spread attributable to adverse selection, and “ε_t” is the serially uncorrelated public information shock.

Neither of the options is in any way in questioned or challenged, as their interest and importance have been demonstrated in recent decades. However, since there are price variations in prices with no apparent justification or public information that would give support for them, the two following questions arise:

1) Is market makers' behaviour homogeneous when faced with the danger of market abuse of dominance?

2) Can the spread be represented in parameters by any known distribution?

The answer to these questions is given by taking option (iii), which option was chosen for the present research. Hitherto, this approach has not been attempted by other researchers studying either the EASDAQ (Nasdaq Europe) or other markets. Table 2 describes the methodological scheme used.

Table 2: Methodological Scheme

STEP 1 - Definition of the POPULATION under study and choice of a representative selection of the traded in EASDAQ, taking into account the criteria of listed status, liquidity and volume
STEP 2 - Description of the variables considered significant for the study of this population. Establishment of a "samples matrix" of observations for each "individual". Characterization of the stocks studied that make up each sample so as to be able to compare stocks, in particular, with the EASI index.
STEP 3 - Stratification of the population according to the variables observed (sample selection) and classification of individuals by means of multivariate (cluster) analysis techniques.
STEP 4 - Descriptive study carried out on the variables, summarized by their position (range, arithmetical mean, median, quantile, …), dispersion measurements (variance, standard deviation, variation co-efficient…) of sharpness or flatness (kurtosis) and of symmetry/asymmetry.
STEP 5 - Data distribution is analysed, comparing observations with known parameter distributions (Normal/Gaussian, Uniform, Poisson and Exponential distributions).
STEP 6 – If necessary, the fulfilment of the requirements of parametric statistical models is checked (normality, independence, homoscedasticity, etc.).
STEP 7 - The ideal test for comparing the samples corresponding to observations of prices and volume offered is specified. The hypothesis of asymmetry is contrasted (non-parametric statistical inference).
STEP 8 - Samples are analysed, according to their nature, as a whole, at layer and grouping level, for all the stocks belonging to the segment representing the population. Depending on the results obtained, the hypothesis is accepted or rejected for the various groups analysed.
STEP 9 - The relationships between significant differences in the quotes and spread sizes are described with respect to the EASI index evolution.
STEP 10 - The conclusions emerging from the results obtained are presented for the various groups studied.

SOURCE: Original compilation by authors

3.5. Considerations and Hypotheses

We are analysing a market which is basically price-driven and where there are market makers whose role is to contrast investors' orders with respect to size and price. We assume market makers act in a rational way, adjusting their quoted buying and selling prices to their profitability expectations and trying to mitigate the risks taken by keeping a portfolio in spite of differentials set, that is, through spread. Thus, we can consider spread to be a barometer that measures the market's "asymmetric pressure". At any moment, it is possible to differentiate the percentage magnitude of the adverse selection component from the remaining factors (maintenance costs and operational costs) for given stocks. Hence, in this context, the following hypothesis may be made:

Under normal conditions, where no variation in portfolio maintenance or operational costs exists, intermediaries will adjust the spread (quotes for orders accepted and pending execution on the market) to their benefit, based on the expected information asymmetries.

Therefore, determining the existence of significant variations in the spread may be considered the initial point of reference for studying the existence of information asymmetries. However, because a market maker can set prices that are not attractive to investors and as a result of the portfolio management and specific strategies, it is necessary to consider its real liquidity and assess the "overall spread" or range of daily trading (the difference between the highest and lowest prices quoted). Stock exchange behaviour within a sector should be similar for all firms comprising the sector, taking into account any individual peculiarities they may have. Thus, the presence of any abnormal variation can be considered an indicator of information asymmetry. Because individual profitability obtained by anonymous investors is hard to define, the highest, lowest, opening and closing prices, together with their evolution over time, will be used so as to achieve an appropriate classification of the stock studied.

Following the methodological scheme explained above, the population was defined (STEP 1) as being composed of the stock traded on EASDAQ. The *Listed Segment* was chosen as representative of the stocks concerned (individuals making up the population), taking into account criteria of listing, liquidity and volume traded. The appended table lists the names of the stocks quoted on EASDAQ, the symbol used by the market, the code given to the firm issuing the stock and the currency in which trading takes place.

Table 3: Listed Segment of the EASDAQ Market

Name	*Symbol*	*Firm*	*Currency*
4Front Technologies	FFTI	1	USD
ActivCard	ACTI	2	USD
AISoftw@re SpA	AISW	3	EUR
Algo Vision plc	AVSN	4	USD
Algol	ALGL	5	EUR
Antisoma	ASOM	6	GBP
Artwork Systems	AWSG	7	EUR
Autonomy Corp.	AUTN	8	USD
Bricsnet N.V.	BSNT	9	EUR
Chemunex	CHMX	10	EUR
City Bird Holding	CBIR	11	USD
Custom Silicon	CSCS	12	EUR
Debonair Holdings	DEBA	13	GBP
Deltex Medical Grp	DLTX	14	USD
Dialog Semicon.	DLGS	15	EUR
EDAP TMS	EDAP	16	USD
EPIQ	EPIQ	17	EUR
Espace Prod. Int'l.	EPIS	18	EUR
Eybl Int'l	EYBL	19	EUR
F.L.V. Fund	FLVF	20	USD
F.L.V. Fund Warrants	FLVFwt	21	USD
Global Graphics	GLGR	22	EUR
Global TeleSystems, Inc	GTSG	23	USD
Granger Telecom	GRAN	24	USD
Gruppo Formula	GFOR	25	EUR
I.T. Int. Theatres	ITIT	26	USD
ICOS Vision Syst.	IVIS	27	USD
Impath Inc.	IMPH	28	USD
Innogenetics	INNX	29	EUR
Integr. Surg. Syst.	RDOC	30	EUR
IQE plc	IQEP	31	USD
Jazztel plc	JAZZ	32	EUR
JSB Software Tech.	SRFC	33	USD
Keyware Technologies	KEYW	34	USD
Lernout & Hauspie	LHSP	35	USD
MBA Michael Bailey	MBAM	36	EUR
Melexis	MLXS	37	EUR
MEMY/TORRIDON PLC	TORR	38	USD
Mercer Int'l	MERC	39	USD
Meta4 NV	MFOR	40	EUR
NBC Internet, Inc.	NBCI	41	USD
NDS Group plc	NNDS	42	USD
NTL	NTLI	43	USD
Option Int'l	OPIN	44	USD
Orthovita, Inc.	VITA	45	USD
Pankl Racing Syst.	PARS	46	EUR
Pharming	PHAR	47	EUR
Pharmos Corporation	PHRM	48	USD
PixTech	PIXT	49	USD
Prime Response	PRME	50	USD
Pro-Laser Ltd	PROL	51	EUR
Royal Olympic	ROCL	52	EUR
S&T Syst Integrat.	SNTS	53	EUR
Schoeller-Bleckmann	SBOE	54	EUR
Supercom Ltd	SPRC	55	USD
Swan S.A.	SWAN	56	EUR
TelDaFax	TDFX	57	EUR
Topcall Int'l	TOPC	58	EUR
Turbodyne Technol.	TRBD	59	USD
UBIZEN	UBIZ	60	EUR
Uproar	UPRO	61	EUR
Uproar (restricted)	UPROrs	62	EUR
Vasco Data Sec. Int'l.	VDSI	63	USD
YLINE Internet Bus.	YLIN	64	EUR

SOURCE: Own compilation, using information taken from *www.nasdaqeurope.com*

The significant variables for this segment were described and a sample matrix of 52,587 rows and 18 columns was formed from observations from the second quarter of 2000 (STEP 2). This matrix layout simplified handling the information at both layer and grouping levels, according to the sample selection and Cluster Analysis performed (STEP 3). Statistics studies summing up market observations for the second quarter of 2000 (STEP 4), together with parametric distribution tests (STEP 5), showed that the sub-samples formed by observing variables such as Best Bid Price, Best Bid Size, Best Offer Price, Best Bid Size, Spread and Spread_p, for the various stocks traded on EASDAQ, do not fall into any recognisable distribution.

3.6. Test For Homogeneity of Information Asymmetries

The theories put forward by researchers interested in breaking down and estimating spread indicate that, in the absence of information asymmetries, or similarly, in case of expected zero risk of abuse of dominance, there will be no adverse selection component as such (it would be 0%). In this case, the spread would only include operational and portfolio holding cost components. Furthermore, when there is asymmetry of information (expected risk of market dominance greater than zero), and assuming that operational and portfolio holding costs remain constant, the component related to information asymmetries should also remain constant. In other words, the distribution functions of the samples in *Spread_p* observed for each stock should be similar. In this context the *Hypothesis of Homogeneity of Information Asymmetries* (HIA) is promulgated:

The percentage variation in the spread follows the same distribution model regardless of the stock being traded. To test this *Hypothesis of Homogeneity of Information Asymmetries*, *k random variables* with a continuous distribution are considered:

$\mathbf{X_1}$ = **“ *Spread_p* Observations for *Issue 1*”**
$\mathbf{X_2}$ = **“*Spread_p* Observations for *Issue 2*”**
... **.....**
$\mathbf{X_k}$ = **“*Spread_p* Observations for *Issue k*”** ***where*** $\mathbf{k \in [1, 2, ..., 64]}$

and the following *hypothesis test* is undertaken:

$$\mathbf{H_0 : F_{X_1} = F_{X_2} = ... = F_{X_{k-1}} = F_{X_k}}$$
$$\mathbf{H_1 : F_{X_i} \neq F_{X_j}\ ;\ for\ some\ i \neq j}$$

where $\mathbf{F_{X_1}}$, $\mathbf{F_{X_2}}$, ..., $\mathbf{F_{X_k}}$ are the distribution functions for $\mathbf{X_1}$, $\mathbf{X_2}$, ..., $\mathbf{X_k}$, respectively.

The null hypothesis, $\mathbf{H_0}$, states that $\mathbf{F_{X_1}}$, $\mathbf{F_{X_2}}$, ..., $\mathbf{F_{X_{k-1}}}$ and $\mathbf{F_{X_k}}$ have the same distribution, in contrast to the alternative hypothesis $\mathbf{H_1}$ (two or more distributions do no coincide).

When testing a statistical hypothesis two types of error can occur:

- **TYPE I ERROR (E_I).-** This error occurs when the null hypothesis, H_0, is rejected although it is true.
- **TYPE II ERROR (E_{II}).-** This error occurs when the alternative hypothesis, H_1, is accepted although it is false.

Since it is impossible to reduce both E_I and E_{II} errors simultaneously, a level of significance or test size α is fixed, small enough to limit the probability of *TYPE I errors*, thus setting the *reliability level of the test* at (**1- α**).

In light of the descriptive and inferential statistical analyses previously undertaken (STEPS 4 and 5), the use of parametric models was ruled out[10]. In their absence, specific nonparametric tests[11] were used, to compare the distribution of k independent samples (STEP 7), namely: the *Kruskal-Wallis Test* and the *Median Test.*

3.6.1. Kruskal-Wallis Test

This test, which compares the distribution of k independent samples of different sizes, was put forward by *Kruskal* and *Wallis* in 1952[12]. Its formula may be viewed as a nonparametric version of the tests developed from *Fisher's Theorem*, as applied to compare the average of k normal populations with a common variance[13]. Using this test, it would be a mistake to use typified variables or any other sort of variables related to the average, as the results would be of no interest. The *Kruskal* and *Wallis* approach is as follows:

[10] Considering the specific features of the above described variables, the following techniques were used to detect the existence and distribution of information asymmetries on EASDAQ: stratified sample selection, descriptive statistics and inferential statistics (parametric and nonparametric analysis tools). Thus, a preliminary descriptive analytical analysis has been performed in order to determine the fulfilment of the parametric statistical models requirements. The results show absence of normality, which justified the use of nonparametric statistical inference models.

[11] Nonparametric Statistics bases its conclusions in the characteristics of the samples ordered, the range of the samples, medians, empirical distributions, etc as compared to Parametric Statistics whose inferences deal with determining patterns on the sample distribution, which responds to a known pattern (Binomial Distribution, Poisson Distribution, Normal Distribution, Fisher Distribution, Student Distribution…). In these cases the models presented introduce contrasts on statistical data based on samples median and/or variance (Cuadras, 1982). When the distribution of the variables is unknown, or there is evidence to believe there is a deviation, it is convenient to perform Nonparametric Statistical analysis. Normality tests used show the expected condition: normality is not achieved. As a matter of fact, the variables used do not follow any known distribution. Besides, the requirements in most of the parametric contrasts include independence and multivariate homoscedasticity (Bizquerra, 1989). These limitations are hardly ever found in stock market quotations and in the market trading volumes.

[12] See CONOVER, W. J. (1999): Practical Nonparametric Statistics, Third Edition, Wiley Series in Probability and Statistics: Applied Probability and Statistics Section. John Wiley & Sons, Inc., USA, pp. 288-290.

[13] See CUADRAS, C. M. (1982): Problemas de Probabilidades y Estadística, Vol. 2: Inferencia Estadística, Promociones y Publicaciones Universitarias. Barcelona, p.13.7.

Given k random samples of sizes: $\mathbf{n_1}$, $\mathbf{n_2}$, ..., $\mathbf{n_k}$, generated from the data observed for k random variables $\mathbf{X_1}$, $\mathbf{X_2}$, ...,$\mathbf{X_k}$, represented by the following scheme:

Sample 1	**Sample 2**	.....	**Sample k**
$\mathbf{X_{1,1}}$	$\mathbf{X_{2,1}}$	.....	$\mathbf{X_{k,1}}$
$\mathbf{X_{1,2}}$	$\mathbf{X_{2,2}}$	.....	$\mathbf{X_{k,2}}$
...	...	.....	...
$\mathbf{X_{1,n_1}}$	$\mathbf{X_{2,n_2}}$	.....	$\mathbf{X_{k,n_k}}$

the following *hypothesis test* can put forward:

$$\mathbf{H_0 : F_{X_1} = F_{X_2} = ... = F_{X_{k-1}} = F_{X_k}}$$
$$\mathbf{H_1 : F_{X_i} \neq F_{X_j}\ ; \text{for some } i \neq j}$$

where $\mathbf{F_{X_1}}$, $\mathbf{F_{X_2}}$, ..., $\mathbf{F_{X_k}}$ are the distribution functions for $\mathbf{X_1}$, $\mathbf{X_2}$, ..., $\mathbf{X_k}$, respectively. In order to make the right decision (to accept or reject $\mathbf{H_0}$**),** observations are ordered by increasing size, represented by $\mathbf{N} = \sum_{i=1}^{k} n_i$, and the corresponding rank (1, 2, ..., n) is given to each sample value (Rank 1 is given to the smallest stock observed, rank 2 to the next and so on). If the distributions of the k groups are homogenous, the statistical formula is:

$$H = \left(\frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} \right) - 3(N+1)$$

where $\mathbf{R_i}$, the sum of the ranks of the samples corresponding to *group i*, is chi-squared with k-1 degrees of freedom, when sample sizes $\mathbf{n_i}$ are large enough (as is the case here).
If there are ties (identical observed values within a sample or in different samples)[14], ranks are averaged, **H** is calculated and thereafter **H'**, given by the following formula:

$$H' = \frac{H}{1 - \left[\sum_{i=1}^{g} (t_i^3 - t_i) \right] / (N^3 - N)}$$

where *g* is the number of different observations presenting ties and t_i is the number of observations tied to a given rank. As **H' > H**, if **H** is significant, it is not necessary to calculate **H'**. If there are no ties, the two figures will coincide, since the parameters t_i and *g* take on values 1 and n, respectively. Section 3.7. describes the results obtained by using the *Kruskal-Wallis Test* to check the *Hypothesis of Homogeneity of Information Asymmetries* (HIA) when considering the k random variables defined in Section 3.6.

[14] See CUADRAS, C. M. (1982): Problemas de Probabilidades y Estadística, Vol. 2: Inferencia Estadística, Promociones y Publicaciones Universitarias. Barcelona, p. 13.8.

3.6.2. Median Test

Comparison of k independent samples obtained from observing one or more random variables whose distribution does not correspond to a known parametric model can be carried out using the *Median Test*. Thus, if the values observed fall above or below the median (as found for the whole set of observations), it is possible to accept or reject the null hypothesis:

H^*_0: ***"All the samples have the same median"***

or similarly, to reject or accept the alternative hypothesis:

H^*_1: ***"There are two or more samples with different medians"***

The formula for this test[15] is useful when solving decision problems based in equal sample distributions. If the medians are not equal, the distribution functions do not coincide. If k random samples with sizes $\mathbf{n_1}$, $\mathbf{n_2}$, ..., $\mathbf{n_k}$, generated from the data observed for k random variables $\mathbf{X_1}$, $\mathbf{X_2}$, ...,$\mathbf{X_k}$, represented by $\mathbf{N} = \sum_{i=1}^{k} n_i$ denote the total number of observations, it is possible to construct a table summarising the positioning of the data belonging to each sample with respect to the median of the whole set in the following format:

SAMPLE	**1**	**2**	**...**	**K**	**TOTAL**
> Median	$O_{1,1}$	$O_{1,2}$	**...**	$O_{1,K}$	***a***
≤ Median	$O_{2,1}$	$O_{2,2}$	**...**	$O_{2,K}$	***b***
TOTAL	$\mathbf{n_1}$	$\mathbf{n_2}$	**...**	$\mathbf{n_K}$	**N**

where ***a*** is the total number of observations situated above the median (determined for the whole set of observations) and ***b*** is the total number of observations equal to or less than the value of the median. To test the null hypothesis, $\mathbf{H^*_0}$, against the alternative hypothesis, $\mathbf{H^*_1}$, the following formula is considered:

$$T = \frac{N^2}{a\,b} \sum_{i=1}^{k} \frac{\left(O_{1,i} - \frac{n_i a}{N}\right)^2}{n_i}$$

whose distribution comes close to a chi-squared distribution with k-1 degrees of freedom.

[15] See CONOVER, W. J. (1999): Practical Nonparametric Statistics, Third Edition, Wiley Series in Probability and Statistics: Applied Probability and Statistics Section. John Wiley & Sons, Inc., USA, pp. 218-224.

In the case considered here, accepting $\mathbf{H^*_1}$ would necessarily imply rejecting the *Hypothesis of Homogeneity of Information Asymmetries* (HIA): *the percentage differences in the spread follow the same model of distribution regardless the stock being traded.* Hence, testing $\mathbf{H^*_0}$ against $\mathbf{H^*_1}$, may be considered a partial alternative[16] to the *hypothesis test* normally used to validate identity of distribution functions, that is:

$$\mathbf{H_0 : F_{X_1} = F_{X_2} = ... = F_{X_{k-1}} = F_{X_k}}$$
$$\mathbf{H_1 : F_{X_i} \neq F_{X_j}\ ;\ for\ some\ i \neq j}$$

where $\mathbf{F_{X_1}}$, $\mathbf{F_{X_2}}$, ..., $\mathbf{F_{X_k}}$ are the distribution functions for $\mathbf{X_1}$, $\mathbf{X_2}$, ..., $\mathbf{X_k}$, respectively.

Section 3.7. shows the results obtained by using the *Median Test* to check indirectly on the *Hypothesis of Homogeneity of Asymmetry of Information*.

3.7. Results of the Study

The results of the *Kruskal-Wallis Test* and the *Median Test* are shown below. They consider observations for the variable "***Spread_p***" for the various issues quoted in the *Listed Segment* of EASDAQ during the second quarter of 2000. Information for each monthly period (April, May and June), is included in an ordered manner:

1. Graph of the *number of observations of the spread* for each of the stocks quoted on EASDAQ.

2. Table summarising the *test statistics* calculated when using the *Kruskal-Wallis Test*.

3. Table of positioning and test statistics assessed on the basis of the *Median Test*.

[16] Accepting H^*_1, as opposed to the alternative hypothesis H^*_0, implies rejecting H_0, although, conversely, accepting H^*_0 (same medians) does not equate to accepting H_0 (identical distribution functions).

Figure 1: ***Results of Non-Parametric Testing - APRIL 2000***

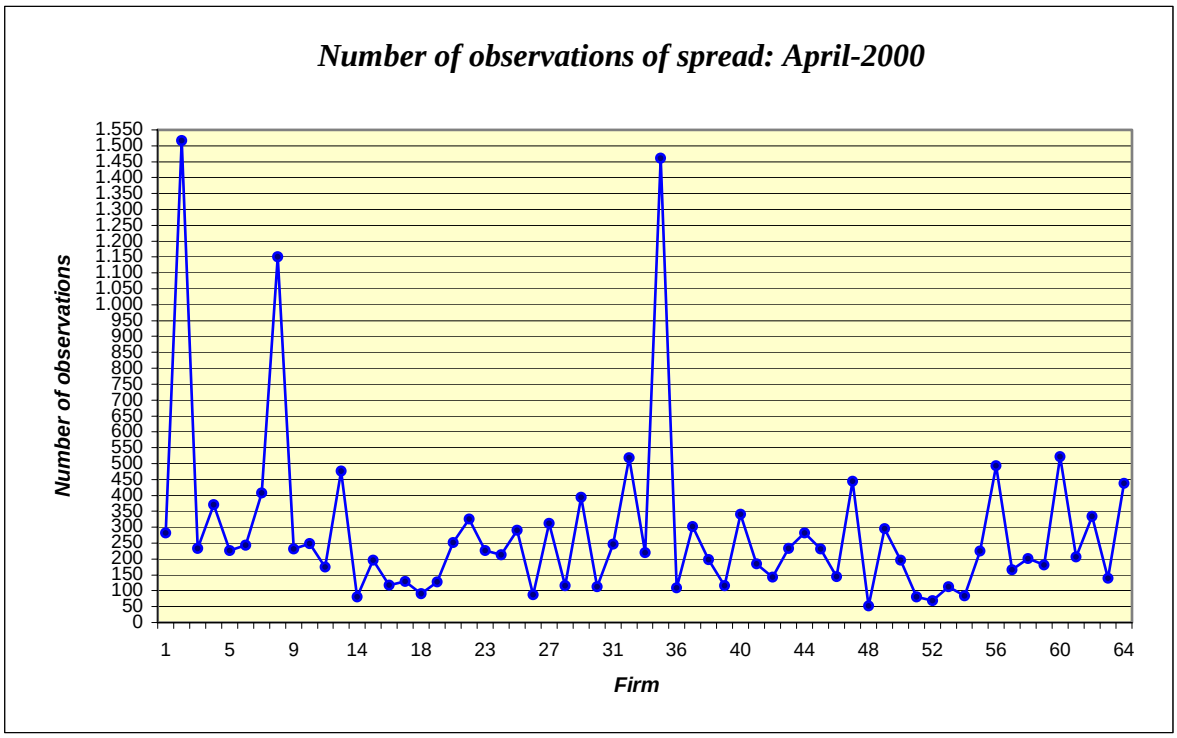

Figure 2: ***KRUSKAL-WALLIS Test***

Tests statistics: April-2000

	SPREAD_P
Chi-squared	**11,360.135**
Degrees of freedom	**60**
Asymtotic significance	**0.000**

Grouping variable: FIRM

Figure 3: ***Median Test***

Tests statistics: April-2000

	SPREAD_P
N	**17,594**
Median	**1.07446813583374**
Chi-squared	**8,667.743**
Degrees of freedom	**60**
Asymtotic significance	**0.000**

Grouping variable: FIRM

Figure 4: ***Results of Non-Parametric Testing - MAY 2000***

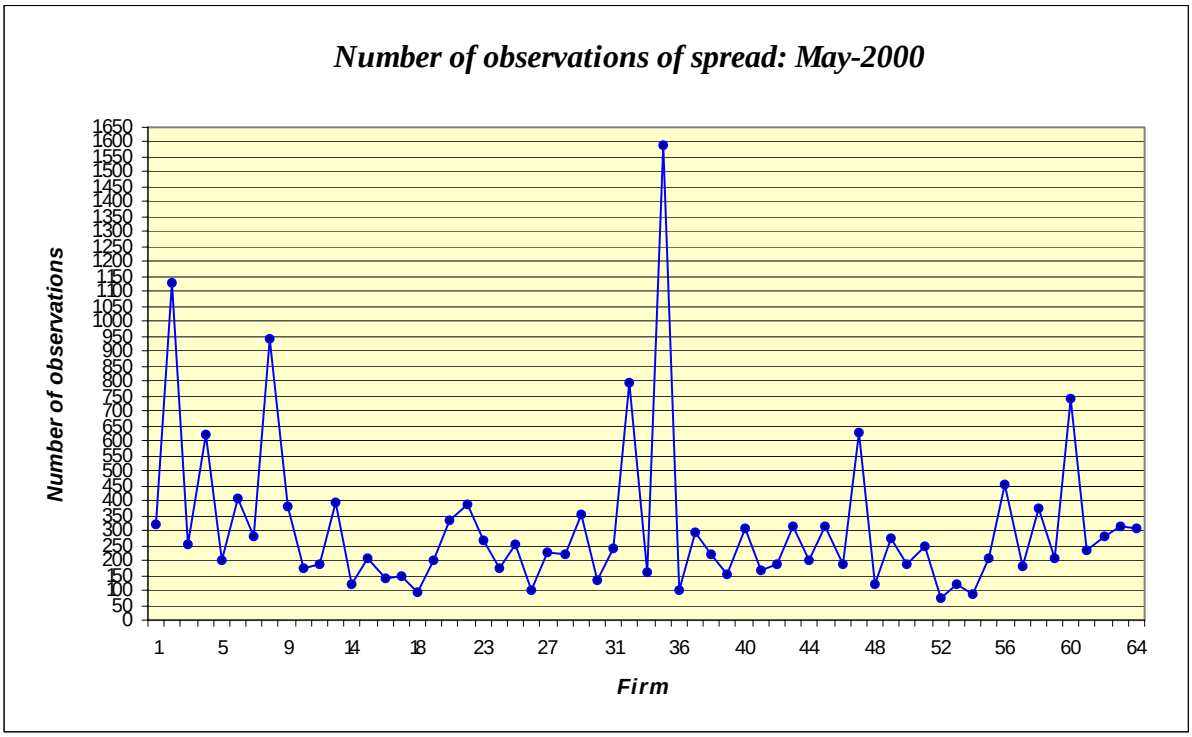

Figure 5: ***KRUSKAL-WALLIS Test***

Tests statistics: May-2000

	SPREAD_P
Chi-squared	**13,378.995**
Degrees of freedom	**60**
Asymtotic significance	**0.000**

Grouping variable: FIRM

Figure 6: ***Median Test***

Tests statistics: May-2000

	SPREAD_P
N	**18,933**
Median	**1.06250000000000**
Chi-squared	**10,922.179**
Degrees of freedom	**60**
Asymtotic significance	**0.000**

Grouping variable: FIRM

Figure 7: ***Results of Non-Parametric Testing - JUNE 2000***

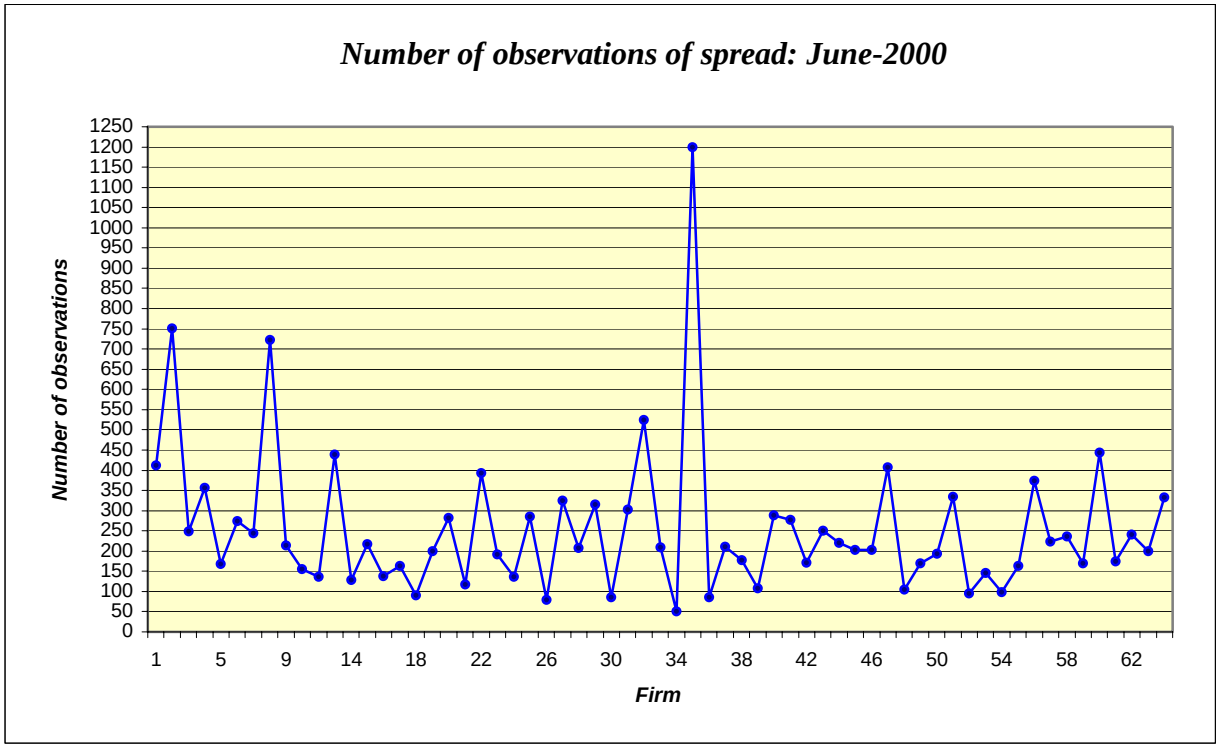

Figure 8: ***KRUSKAL- WALLIS Test***

Tests statistics: June-2000

	SPREAD_P
Chi-squared	**11,824.771**
Degrees of freedom	**62**
Asymtotic significance	**0.000**

Grouping variable: FIRM

Figure 9: ***Median Test***

Tests statistics: June-2000

	SPREAD_P
N	**16,060**
Median	**1.0545454025268**
Chi-squared	**9,430.986**
Degrees of freedom	**62**
Asymtotic significance	**0.000**

Grouping variable: FIRM

The graphs show month by month similarities with respect to data forming the various samples selected: April, May and June. A total of 52,587 observations of the Percentage Spread[17] were analysed, of which 17,594 correspond to April, 18,933 to May and 16,060 to June. The following firms stand out:

N 2.- ActivCard S.A.[18], with 1,516 observations for April, 1,129 for May and 751 for June.
N 8.- Autonomy Corporation plc.[19], with 1,150 observations for April, 941 for May and 722 for June.
N 35.- Lernout & Hauspie Speech Products[20], with 1,461 observations for April, 1,591 for May and 1,200 for June.

This characteristic, however does not determine the distribution of the samples. In fact, the "statistics" obtained from testing the *Hypothesis of Homogeneity of Information Asymmetries* by means of the *Kruskal Test* lie outside the zone of acceptance, because, as indicated in Section 3.6.1., if there is homogeneity in the distributions of the k samples, the formula:

$$H = \left(\frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} \right) - 3(N+1)$$

where $\mathbf{R_i}$ is the sum of the ranges of the samples in *group i*, has, approximately, a *chi-squared* distribution with k-1 degrees of freedom, when the sizes of samples $\mathbf{n_i}$ are large enough (as is the case here).

The summary tables corresponding to the months of April, May and June show the value **H** (Chi-squared) obtained from the average ranges, previously evaluated for each month, and indicate the number of degrees of freedom ("df" = k-1) corresponding to each period. In all cases the asymptotic significance obtained is equal to 0.000, that is, **H** stands outside the zone of acceptance.

Likewise, the results obtained from testing the *Hypothesis of Homogeneity Information Asymmetries* by means of the *Median Test*, explained in Section 3.6.2., imply the acceptance of the alternative hypothesis. The tables corresponding to April, May and June include the *total number of observations* (N), the *total median* and the value of **T** (*Chi-squared*):

$$T = \frac{N^2}{ab} \sum_{i=1}^{k} \frac{\left(O_{1,i} - \frac{n_i a}{N}\right)^2}{n_i}$$

whose distribution approximates a *chi-squared* with k-1 degrees of freedom (represented in the table of results as "df"). In all cases the *asymptotic significance* obtained is equal to 0.000, that is, **T** does not fall within the zone of acceptance of the test, which corroborates the results of the *Kruskal-Wallis Test*.

[17] This variable, specially introduced in this study, was defined as the percentage difference between the Best Offer Price and the Best Bid Price offered by a market maker, registered as an intermediary to trade a given stock.

[18] An American company that joined this market thanks to issuing shares registered in France. Its activity lies mainly in the development of electronic certificates and digital identities, essential in e-commerce development. Listed on EASDAQ from 20 December 1996 onwards (USD).

[19] A British firm working in the field of software and information technology. On 10 July 1998 it joined the listed segment of EASDAQ (USD).

[20] A Belgian firm traded on EASDAQ from 23 July 1997 onwards (USD). Its operations centre on the development of software, with a wide range of products and services aimed at specialist enterprises in sectors such as health, legal work and the like.

The non-parametric tests used clarify that the samples analysed are not identically distributed and that, for any two or more samples, there are significant differences in medians. Following this line, additional investigation was undertaken to study combinations of two or more samples belonging to the same layer, to the same grouping or to the same stock at different periods in time. In all cases, the results lie outside the zone of acceptance of the null hypothesis; therefore the *Hypothesis of Homogeneity of Information Asymmetries* is rejected (STEP 8).

On the other hand, it was proven that the EASI[21] index summarises quote variations and spread amplitude of the stock in the Listed Segment (STEP 9), regardless of the strategy or positioning of the market makers.

[21] See "EASI. Guide to calculation methods of the EASDAQ All Share Index". EASDAQ S.A. (1999).

4. CONCLUSIONS

The conclusions of this study can be summed up in the following seven points:

i) The European Technology Stocks Market EASDAQ (*Nasdaq Europe*) is a highly regulated market, characterized by a unified flexible system of trading. It is known internationally (both within and outside Europe) and has been able to adapt its operational procedures to the functioning of new stock exchange platforms, incorporating exhaustive supervision controls so as to guarantee access to investors on terms of equality.

ii) Despite the supervision and control policies developed within the framework of the European Union, the risk of insiders trading (individuals abusing the their dominant position on the market) is a determining variable in the spread components.

iii) Actions of the intermediaries (market makers) operating in Price-Driven Markets are conditioned by the risk of existence of information asymmetries. Analysis of the spreads variations (price ranges) for the different stocks quoted allows for extending the study of market asymmetry, without having to undertake biased comparisons of those groups at risk from insider activity, as defined beforehand, which would require the intervention of competent authorities.

iv) Empirical processing of the observations on prices and volumes for listed and traded stocks shows not only that there are information asymmetries on EASDAQ market, as measured from the expected risk of abuse of dominance taken into account by market markers when they introduce the adverse selection component in setting spreads, but also shows the lack of uniformity in the distribution functions of percentage variations in spread related to the different stocks traded in the Listed Segment during the second half of 2000.

v) Consequently, the Hypothesis of Homogeneity of Information Asymmetries is rejected for this market (at the segment, layer, grouping and even at the individual stock levels). This raises new questions and suggests new lines of research relative to the problem of information and how it is handled in technological markets, within the present state of globalisation.

vi) In this context, we question if the supposed risk assumed by intermediaries is proportional to the real risk taken by insiders. It may well be that the defensive attitude of the market makers interferes negatively in price formation, and introduces larger speculative margins than expected.

vii) It is essential to harmonize the regulation standards of European, American and Asian markets, so as to typify trading models used in these three continents. Only thereafter will it be possible to conceive of a "Single Stock Market", with no time restrictions, that brings together dealings of all the various exchanges.

In brief, the work carried out is a new contribution to the Analysis of Information Asymmetries on Stocks Markets. Results evidence fundamental aspects of the heterogeneous behaviour of intermediaries who operate in "Price-Driven Markets", where it has been possible to assess the magnitude of the adverse selection component on spread. In particular, the study introduces a methodological approach to parameterise the variations of spread and the performance of market makers when faced with the risk of abuse of dominance.

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