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# Trade Transparency and Trading Volume: The Possible Impact of the Financial Instruments Markets Directive on the Trading Volume of EU Equity Markets

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**Abstract:** The EC Directive on Financial Instruments Markets 2004 (MiFID) has introduced a number of order and trade publication obligations imposed on organized exchanges, Alternative Trading Systems (ATS), and the class of broker dealers that execute transactions in shares internally. This article investigates the impact of MiFID's trade transparency rules on the trading volume of EU equity markets in a forward-looking mode. We use data extracted from the closest possible precedent and examine trading volume levels before and after trading in FTSE100 stocks on the London Stock Exchange (LSE) shifted from the quote-driven Stock Exchange Automatic Quotation System (SEAQ) to the order-driven Securities Electronic Trading Service (SETS). This change resulted in significantly increased transparency standards. Trading volume is measured on the basis of three criteria: volume-based turnover, value-based turnover and turnover ratio. No evidence is found indicating that higher transparency standards lead per se to higher levels of trading volume. Therefore, the impact of MiFID's transparency rules on trading volume in EU equity markets should become a matter of further study following their implementation.

**JEL:** C14, C22, G18, G28, K22.

**Keywords:** Trading Volume, London Stock Exchange, MiFID, MTFs, Transparency, Regulated Markets, SEAQ, SETS, Systematic Internalisers.

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## 1. Introduction

The EC Directive on Financial Instruments Markets (MiFID)<sup>1</sup> introduces a number of order and trade publication requirements imposed on organized exchanges, called in the Directive regulated markets, qualifying ATSS, called in the Directive Multilateral Trading Facilities (MTFs), and broker dealers that execute internally transactions in shares admitted to trading on an organized market in the EU on an organized and systematic basis, called in the Directive systematic internalisers. These raise significantly the levels of transparency of EU equity markets. This article explores the possible impact of MiFID's rules on trading volume in EU equity markets as a guide for EU policy-making in this area taking also into account the findings of finance and regulation literature on market microstructure.<sup>2</sup> The mere existence of an efficient price discovery mechanism is in itself insufficient if investors want to transact at efficient prices; in other words: '[e]fficient prices, after all, are unimportant if one can transact only a 100-share lot at these prices'.<sup>3</sup> Thus, the actual impact of MiFID's transparency rules on trading volume in EU equity markets will have direct influence on the efficient operation of these markets.

Keynes has suggested that the degree of liquidity of an asset can be measured on the basis of: (a) the riskiness of its final value (ability to realise the asset's value) and (b) the availability of the market to readily absorb the sale of the asset without any serious downward pressure on the price of the asset. The absorptive capacity of the market has been used by certain authors as a measure of liquidity<sup>4</sup> and is to a certain extent dependent on prevailing levels of trading volume. Another criterion for measuring liquidity is the depth of the bid/offer spread in quote driven markets and the difference

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<sup>1</sup> Directive 2004/39/EC of 21 April 2004 on markets in financial instruments, OJ L 145/1.

<sup>2</sup> For an overview see Mahoney (2003), O'Hara (1999), Glosten and Milgrom (1985) and Kini and Mian (1995).

<sup>3</sup> Madhavan *et al.* (2001).

<sup>4</sup> Pagano (1989).

between the best buy and sell limit orders in order driven markets.<sup>5</sup> This article does not purport to measure the liquidity impact of MiFID on EU equity markets but rather to examine its possible effect on trading volume, which, in turn may have a significant bearing on prevailing levels of liquidity. In order to measure trading volume we use three criteria: *volume-based turnover*, *value-based turnover* and *turnover ratio*.

Since MiFID has not yet been implemented in EU Member States, we examine the shift of the LSE from SEAQ to SETS on 20 October 1997 to draw tentative conclusions on MiFID's predicted impact on trading volume. The examined period extends from 22 October 1992 to 18 October 2002. The data set comprises the price, the volume-based turnover and the number of ordinary shares in issue, on a daily basis, for seventy stocks that remained in the FTSE100 index throughout the period under investigation. Thirty stocks did not maintain a presence in the basket of FTSE 100 for the entire post-SETS period. The data was obtained from DataStream<sup>©</sup>.

International financial markets witnessed during the examined period three very important developments. The first development was the radical transformation of market structure through the introduction of ATs. The second development was the advent of Internet trading, which allowed retail investors much higher levels of access to stock trading. The third development was the stock market bubble of the late 1990s, which increased trading volume in a rather non-linear and unexpected manner. If the impact of the aforementioned market developments on trading volume is isolated, then there is no evidence that the enhanced trade transparency standards, which followed the introduction of SETS, increased the market's absorptive capacity.

This article is divided in five sections. The first section is the present introduction. The second section provides a brief discussion of the mechanics of market transparency and its perceived impact on trading volume. The third section explains the new transparency obligations that MiFID imposes on: (a) organized securities markets, (b) Multilateral Trading Facilities, and (c) 'systematic internalisers'. The fourth section examines the impact on trading volume of the LSE's shift from a dealer market to an order-driven

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<sup>5</sup> Pagano (1996). For details about the benchmarks used to measure liquidity based on the bid/offer spread see Amihud and Mendelson (1986), Cheung *et al.* (2003), Chordia *et al.* (2003), Fleming (2001), and Irvine *et al.* (2000).

market. The fifth section brings the different strands of the present discussion to a comprehensive conclusion.

## **2. Market Transparency and Market Welfare**

### *2.1 Defining Market Transparency*

A transparent market is a market that combines three elements: (a) constant flow of issuer specific information, (b) disclosure of material interests in financial assets, and (c) pre- and post-trade dissemination of information about orders and trades. The first two elements are regulated by mandatory disclosure rules and their discussion falls outside the scope of this article.

Price transparency means the public availability of information about superior prices for the conclusion of certain trades specified as to their quantity. Trade transparency means the public availability of information about current trading flows on the market in terms of volume. As a market must be transparent before and after the conclusion of the transaction, relevant rules regulate the level of both pre-trade and post-trade transparency. *Pre-trade transparency* means the availability of data about the size and price of orders flowing to the market, pending execution. Also information about the prices at which a market maker is ready to buy and sell securities of a specified size (quote). *Post-trade transparency* means the availability of information after the conclusion of a transaction, especially information about the specific price, quantity, and time of the transaction. Maximum post-trade transparency would comprise immediate publication of data about the price and volume of each transaction, as well as the identification of the transacting parties.<sup>6</sup>

Order-driven securities markets usually maintain a high level of invisibility of pre-execution orders and price limits imposed on them, until the time of execution. Dealer markets have, usually, high levels of pre-trade transparency. Market makers on the LSE, for instance, before the introduction of SETS, used to post their quotes on SEAQ screens, and this ensured a high level of pre-execution price visibility. On the other hand, post-trade transparency is considerably higher in order-driven markets, which, in general, publish

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<sup>6</sup> Steil (1996, p. 66, note 9).

information about matched trades immediately. In dealer markets, delayed publication of information about completed trades is the norm.<sup>7</sup>

## 2.2 *The Welfare Effects of Market Transparency Rules*

Because of the complexity of the price discovery mechanism market information is of considerable value to those who may wish to trade in the near future. Market participants may employ the so-called ‘trade’ and ‘price decoding’ techniques in order to deduce new information from the posted quotes or incoming order flow, as well as from completed trades.<sup>8</sup> Depending on the reliability of such information and investor’s technical expertise and skill, wide availability of information improves the allocative efficiency of investor trading. This is achieved because a more equitable distribution of actual and potential trading profit opportunities between broker-dealers and market users (outside investors) is ensured by restricting<sup>9</sup> the ability of brokers and exchange members to front-run client trades.

Furthermore, trade transparency rules are introduced as a means to ensure: (a) better execution of client orders and (b) the reduction in the frequency of market abuse in the form of insider dealing and market manipulation, as large trades or their source may, eventually, be detected.<sup>10</sup>

Yet, the producers of trade information, namely, those who have just transacted, cannot be compensated. Thus, the same public-collective good argument employed to justify mandatory disclosure rules<sup>11</sup> may also be used in the present context. Namely, it is assumed that, in the absence of strict publication requirements, trade information would remain under-supplied, favouring internalizing brokers and/or exchange members over outside traders. In the absence, for instance, of rules that oblige broker/dealers to publish investor limit orders on receipt, dealers can front-run client orders,<sup>12</sup> or leave them to expire in order to execute them from their books at a more advantageous price.

However, regulatory initiatives to increase market transparency standards usually face strong opposition that is based on the following arguments:

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<sup>7</sup> Steil (1996, pp. 32-33).

<sup>8</sup> Gilson and Kraakman (1984, pp. 573-575, 577-578).

<sup>9</sup> See Mahoney (1997, pp. 1485-1486).

<sup>10</sup> For the importance of market transparency in safeguarding the integrity of securities markets see Avgouleas (1998).

<sup>11</sup> Coffee (1984) and Mahoney (1995, p.1047).

<sup>12</sup> Board and Sutcliffe (1995, p.2).

- (a) If traders lose their ability to capture most of the value of information they have acquired through hard effort they will cease searching for new information. This development would harm the information efficiency of market prices;
- (b) if traders cannot conceal their positions, until they have extracted the full value of private information, increased transparency standards may cause an outflow of trades from the market concerned. Large traders, in particular, can become very vulnerable. If information about their trades becomes readily available, the market might turn against their positions. Large traders might in response abstain from active trading;
- (c) changes in a market's transparency alter a trader's ability to strategically reveal orders. This results in increased transaction costs and reduced liquidity, because trades are withdrawn to avoid revealing orders to 'noise' and other 'parasitic' traders;<sup>13</sup>
- (d) a requirement of immediate publication of trade information may penalize market makers, which are legally obliged to provide liquidity in the market for the relevant financial asset.<sup>14</sup> Therefore, trading volume seems to migrate from the very transparent markets to those with lower pre- and post-trade transparency;
- (e) it seems that lower transparency standards reduce transaction spreads, since market makers tend to offer better prices on block trades, when these remain concealed for some time, because they can exploit the information conveyed by such trades.<sup>15</sup>

Nonetheless, many arguments against high standards of market transparency contain loopholes. First, traders that acquire and read accurately new information or reinterpret already available information faster than the rest of the market can, for a while, make superior returns over that information. Secondly, arguments have been offered against the view that high transparency standards inhibit trading volume and liquidity.<sup>16</sup> Increased market transparency standards might, for instance, result in lower instead of higher trading costs and thus increase liquidity. In a dealer market, the dealer is exposed to the danger of being taken advantage of by informed traders. As a result, he widens his bid/offer spread raising the trading costs of uninformed traders. On the other hand, in a relatively transparent market where the dealer is less concerned with the possibility that he might

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<sup>13</sup> Harris (1996).

<sup>14</sup> Market makers usually absorb large positions in their capacity as liquidity providers and subsequently re-balance their inventories in the open market Board and Sutcliffe (1995, pp. 7-19).

<sup>15</sup> Madhavan (1993) and Pagano and Röell (1996).

<sup>16</sup> Pagano (1989).

incur losses to insiders he lowers his spreads decreasing investors' trading costs. The argument applies equally to order-driven markets. Investor monitoring of trading trends becomes easier, and their ability to respond faster to them leads, possibly, to increased trading volume.<sup>17</sup> Also, as experience from the operation of London Inter Dealer Brokers ('IDBs')<sup>18</sup> demonstrates, the withholding of trade information is not used by market dealers only in order to protect their trades, but also in order to provide inaccessible trade information to selected clients.<sup>19</sup> In addition, it seems that the rapid publication of post-trade information improves investor confidence that 'they obtain fair prices', possibly, attracting additional order flows.<sup>20</sup>

Moreover, the multiplication of electronic trading channels, as, for instance, the ATSS,<sup>21</sup> makes market transparency a matter of cardinal importance for reasons of protection of the integrity of the price formation mechanism. In this context, another issue that has emerged over the recent years is the transparency of executing brokers' order books, especially in respect of limit orders and above all the transparency of transactions executed internally by highly integrated financial institutions. These have the ability to execute a client's order against a proprietary position or match internally two opposite client orders without having to send it to an exchange or an ATS for execution. It is unlikely that, in the absence of very large trades, which are subject to mandatory reporting requirements, the marketplace will receive information about the details of such transactions in a timely manner. The issue of internalization was one of the most controversial topics that MiFID has sought to regulate. It raises concerns about the information efficiency of securities markets' price formation mechanism, because of limited availability of price and trade information and trade fragmentation, and issues of best execution of investors' orders.<sup>22</sup>

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<sup>17</sup> e.g. the display of limit orders may encourage new limit orders to be submitted.

<sup>18</sup> On the LSE market makers' trades executed through IDBs were not appearing on the main SEAQ screens and thus were visible only to dealers allowed to trade on that system. The restriction of access to IDBs' systems for non LSE members was abolished by the LSE Notice of Rule Amendments N74/97, 16 October 1997.

<sup>19</sup> This custom allowed large traders with close links with securities dealers to trade at better prices than the average investor. Steil (1996, p. 37) and O'Hara (1995, p. 164).

<sup>20</sup> Gemmill, (1994, pp.26-27).

<sup>21</sup> See Harris (1993).

<sup>22</sup> Avgouleas (2005, pp 336-349).



Notwithstanding the above, accepting that market transparency plays a very crucial role in ensuring the fair operation of financial markets does not mean that financial exchanges and their members should not ascertain property rights over market (trade and price) information.<sup>23</sup> In the highly competitive environment that these operate, selling financial information constitutes a very legitimate source of income. Exchanges can negotiate with interested investors information access agreements on a purely commercial basis.<sup>24</sup>

Exchanges, ATs and internalizing brokers should, however, have no right to restrict access to trade information to any investor who is willing to pay the required price, in much the same way that lighthouses could not discriminate against passing ships in nineteenth century Britain, which, as Coase proved, was not a public service but was financed through levies raised on shippers.<sup>25</sup> A modified version of this approach is, arguably, followed by MiFID, which seems to allow (through the use of the term: on ‘reasonable commercial terms’) commercial negotiations between investors and other users of market data and operators of both MTFs<sup>26</sup> and organized exchanges<sup>27</sup> for the right to have direct and immediate access to pre- and post-trade information. In this sense, market information preserves its ‘public/collective good’ character, while members or owners of the facility on which such information is generated are compensated for their services.<sup>28</sup>

### **3. MiFID Rules on Market Transparency**

#### *3.1 The Transparency Obligations of Regulated Markets*

MiFID imposes on operators of both MTFs<sup>29</sup> and regulated markets (exchanges)<sup>30</sup> obligations for the timely publication of pre- and post-trade information. This information covers bid and offer prices, the depth of trading interest and order flow, volume, price

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<sup>23</sup> Mulherin *et al.* (1991) and Mahoney (1997, p. 1479).

<sup>24</sup> See also Mulherin *et al.* (1991, pp. 633-637) and Mahoney (1997, pp. 1480-1481).

<sup>25</sup> Coase (1974, p.357).

<sup>26</sup> MiFID, Arts 29 and 30.

<sup>27</sup> Arts 44 and 45.

<sup>28</sup> See also Mahoney (1997, pp. 1481-1482).

<sup>29</sup> MiFID, Arts 29 and 30.

<sup>30</sup> Arts 44 and 45.

and the time of completed trades, in respect of shares admitted to trading on a regulated market.

The pre-trade transparency obligations of regulated markets involve the continuous publication of information about:

- (a) Current bid and offer prices which are advertised through their systems for shares admitted to trading (pre-trade transparency);<sup>31</sup>
- (b) the specific types of order, the bid/offer spread in order-driven markets.

The types and size of quotes that designated market-makers in quote-driven markets will be required to publish are to be determined by subsequent legislation, the so-called Level 2 implementing measures.<sup>32</sup> The display of large size orders and quotes or of orders and quotes in illiquid securities may be exempted,<sup>33</sup> as such display may inhibit liquidity.

In the case of completed trades, regulated markets have the obligation to publish the price, volume and time for all trades in equity instruments ‘concluded under the rules and systems of the market on a reasonable commercial basis and as close to real time as possible’<sup>34</sup> (post-trade transparency). The reporting of the details of large trades and trades in illiquid securities could be deferred. The range of orders/quotes to be disclosed will also be defined by Level 2 implementing measures.

### 3.2 *The Transparency Obligations of MTFs*

Among other obligations imposed by MiFID on investment firms and market operators is the objective, fair, timely and efficient handling of trading interests expressed through MTFs.<sup>35</sup> The authors of the Directive have tried to achieve this objective through, *inter alia*, the imposition of pre- and post-trade transparency obligations in respect of equity transactions concluded on MTFs,<sup>36</sup> which are largely symmetrical with the transparency obligations imposed by MiFID on regulated markets for similar orders or transactions displayed on or concluded through such markets. MTF operators have no post-trade transparency obligations, namely, the obligation to publish data on concluded trades,

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<sup>31</sup> MiFID, Art. 44(1).

<sup>32</sup> On the structure and workings of the so-called Lamfalussy process, the method used for the production of financial services legislation in the EU, see Avgouleas (2005, pp. 328-333).

<sup>33</sup> MiFID, Art. 44(2).

<sup>34</sup> Art. 45(1).

<sup>35</sup> Art. 14(1).

<sup>36</sup> Arts 29 and 30.

where relevant information is made public under the system of a regulated market.<sup>37</sup> Possibilities for deferral of trade reporting, and the range/depth of pre-trade disclosure are quite similar to those applicable to regulated markets.<sup>38</sup> Also, auction-crossing systems and other types of MTFs, which do not involve prior disclosure of firm indication for prices, may be exempted from the scope of the pre-trade transparency obligation.<sup>39</sup>

### 3.3. *The Transparency Obligations of ‘Systematic Internalisers’*

Article 27 of the MiFID, which places pre-trade disclosure obligations on investment firms that act as ‘systematic internalisers’<sup>40</sup> is one of the most controversial provisions of the Directive, and was considered by many in the industry as very intrusive to investment firms’ economic freedom.

Article 27 requires investment firms, which execute client orders in shares internally and outside of a regulated market or an MTF on an organized and systematic basis to publish firm quotes, namely to disclose to the market the prices at which they would be willing to buy from and/or to sell to their clients shares admitted to trading in a regulated market.<sup>41</sup> The publication obligation is limited to transactions up to ‘standard market size’, defined as the ‘average size’ for the orders executed in those shares on EU markets.<sup>42</sup> This provision ensures that European wholesale markets are not be subject to the rule and thus wholesale broker-dealers shall not be exposed to significant risks in their role as market makers.

‘Systematic internalisers’ must make public their quotes regularly and continuously, during normal trading hours. As firms are obliged to make public such quotes on a reasonable commercial basis, MiFID allows ‘systematic internalisers’ to decide the group of clients to whom they shall make such quotes available (retail or professional),<sup>43</sup> and the number of transactions they may undertake from the same

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<sup>37</sup> Art. 30(1).

<sup>38</sup> Arts 29(2) and 30(2). Art. 30(2) requires MTFs to obtain the competent authority’s prior approval in respect of arrangements governing deferred trade publication.

<sup>39</sup> Art. 29 (2) and (3)(c).

<sup>40</sup> Art. 4(7) of MiFID defines as ‘systematic internalisers’ investment firms, which, on an organised, regular, and systematic basis, deal on own account by buying and selling financial instruments against their proprietary capital.

<sup>41</sup> Art. 27(1).

<sup>42</sup> Ibid.

<sup>43</sup> MiFID Art. 27(3).

client.<sup>44</sup> The same firms have post-trade transparency obligations for transactions in shares admitted to trading on a regulated market, which they execute internally and outside of a regulated market or an MTF. They must make public details of such transactions ‘as close to real time as possible’.<sup>45</sup>

Given the importance of the terms ‘standard market size’ and ‘average size’, it is not surprising that the debate in the EU as to the content that should be given in these terms in the forthcoming EU Directive, which as a Level 2 implementing measure, in accordance with the Lamfalussy process, will give meaning to many of MiFID’s opaque concepts, is quite heated. Providing definitions that are not expansive enough as to cover the majority of medium size trades in equities may be of crucial importance for maintaining and increasing trading volume in EU equity markets, in view of ever growing global competition for the provision of trade intermediation and execution services. For this reason, one of the central themes of this paper is to raise awareness about the adverse consequences that the restrictive content of market maker’s obligation to timely publish their quotes in regulated markets (Article 44(3)) and the reach of systematic internalisers’ order and trade publication requirements may have on EU equity markets.

#### **4. Measuring the Impact of Transparency Rules on Trading Volume**

##### *4.1 Identifying the Appropriate Benchmark to Measure Trading Volume*

There is an extensive literature dealing with measures of trading volume. Andersen (1996), Campbell *et al.* (1993), Gallant *et al.* (1992), Karpoff (1987), Lamoureux and Lastrapes (1994), and Lo and Wang (2000) are some of the studies that investigate the properties of various measures of volume. Karpoff (1987) and Lo and Wang (2000) have reviewed the most important surveys of measures of trading volume. Based mainly on the relevant study of Lo and Wang (2000), we use the following three measures of trading volume:

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<sup>44</sup> Art. 27(4).

<sup>45</sup> Art. 28(1).

- The number of shares traded for asset  $i$  on a particular day  $t$ , called here *volume-based turnover*,  $y_{t,i}$ .
- The number of shares that were traded at the current day's  $t$  closing price, called here *value-based turnover*,  $y_{t,i}P_{t,i}$ .
- The ratio of the value-based turnover to the market value:  $(y_{t,i}P_{t,i})/(Y_{t,i}P_{t,i})$ , where  $Y_{t,i}P_{t,i}$  is the market value of asset  $i$  on day  $t$ , and  $Y_{t,i}$  represents the ordinary shares in issue of company  $i$  at current date  $t$ . Note that the number of shares traded to the total number of shares outstanding, or  $y_{t,i}/Y_{t,i}$ , gives the same result. Datar *et al.* (1998) have used *turnover ratio* (number of shares traded as a fraction of the number of shares outstanding) as a proxy for liquidity, in order to provide an alternative measure of liquidity to Amihud and Mendelson's (1986) posted bid/offer spread.

We use a sample that covers the period from October 22, 1992 to October 18, 2002. The data set consists of the price, the volume-based turnover and the number of ordinary shares in issue, on a daily basis, for seventy stocks that belong to the FTSE100 index during the period that is investigated. The data were obtained from DataStream. Both the pre-SETS and post-SETS sample periods consist of 1262 trading days.<sup>46</sup>

#### INSERT FIGURE 1 ABOUT HERE

Figure 1 depicts the price index, volume-based turnover, value-based turnover and the turnover ratio for the FTSE100 index from October 22, 1992 to October 18, 2002. From a visual inspection, all three measures of trading volume are clearly higher in the post-SETS period. However, there are two main drawbacks in using the volume-based turnover and value-based turnover criteria. The number of shares outstanding has an increasing trend, which drives, by default, volume-based turnover to higher levels. Moreover, the price levels in the post-SETS period, due to the stock market bubble, are higher than in the pre-SETS period driving, by default, to higher levels the value-based turnover. So, it may be proper to devise a measure of trading volume that links, in a standard form, trading turnover with the total value of the market. Hence, the turnover

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<sup>46</sup> For 2 of the 70 stocks in the sample we examine trading volume over 1153 trading days in the pre-SETS period, because they were admitted to the FTSE100 index on March 29, 1993.

ratio could be identified as the measure of trading volume that remains resistant to market changes, namely, changes in the price of relevant stocks and changes in the number of outstanding shares.

#### 4.2. *The Example of SETS*

As mentioned above, MiFID's rules on market transparency have not yet been implemented. However, we can still draw assumptions as to the possible impact of their implementation on trading volume by examining the impact of analogous measures imposed in the past, which changed the way securities markets published order and trade information. The closest example that can be found is the introduction of increased trade transparency standards in the LSE as a result of its transition from a dealer (quote-driven market) to an order driven market on 20 October 1997, when trading of FTSE100 stocks moved from SEAQ to SETS. Since SETS operated as a central order book, the change ensured higher levels of both pre-trade and more crucially post-trade transparency. However, unlike most central order books, on SETS, pre-trade transparency is also high because the limit orders submitted to the book are visible to all market participants. Thus, SETS displays the full current depth of the order book. SETS has also increased the level of post-trade transparency FTSE100 stocks with the exception of trades exceeding eight times Normal Market Size (NMS), where the trade need not be published until after the dealer has unwound 80 per cent of the original position.<sup>47</sup> This was a major reform, as such trades remained undisclosed for between thirty minutes and several hours under the SEAQ regime.

We shall attempt to illustrate below, in a quantitative manner, that if market developments that are not related to the transition from a dealer to an order driven market on 20 October 1997 are properly accounted for, then there was not, in fact, a statistically significant increase in trading volume levels for FTSE100 stocks that is directly related to changes in the standards of market transparency.

We assume that the variables observed in markets (*i.e.*, equity prices, trading volume) are priced in continuous time, but the relevant data is sampled discretely in time with a constant sample frequency. Hence, we define  $y_{(m)t,i}$ , for  $t = 1/m, 2/m, \dots$ , as a discrete time positive-valued process at day  $t$ , for asset  $i$ , with  $m$  observations per day.

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<sup>47</sup> Ganley *et al.* (1998, p. 3, Table 2).

Accordingly, trading volume may be expressed by measuring levels of trading activity, which are directly observed in discrete points in time. Moreover, we assume a sample frequency of a daily base, or  $m = 1$ , and we rewrite  $y_{(1)t,i} \equiv y_{t,i}$ , for reasons of simplicity. Hence,  $\{y_{t,i}\}_{t=1}^T$  refers to the discretely observed series of trading volume of asset  $i$  at days  $t = 1, 2, \dots, T$ . For the purposes of this paper, we use a sample of data such that the day  $n$ , at which the SEAQ was replaced by SETS, is equal to  $(T/2) + 1$  and we identify two sub-groups: (a)  $1, \dots, T/2$  and (b)  $T/2 + 1, \dots, T$ . Thus, there are  $1, 2, \dots, T/2$  days prior to 20<sup>th</sup> of October 1997 and  $T/2 + 1, T/2 + 2, \dots, T$  days after the introduction of SETS<sup>48</sup>.

### 4.3. Non-parametric Hypothesis Testing

Having already defined the period that will be examined and the stocks that comprise the tested sample we turn now to offer a method to investigate whether the level of trading activity differs prior to and after the enactment of the specific rule at day  $n$ . Figure 2 presents the frequency distribution histogram of the three measures used here to calculate trading volume on FTSE100 stocks during the examined period.

INSERT FIGURE 2 ABOUT HERE

In order to test the null hypothesis that the first subgroup median is greater than or equal to the second subgroup median against the alternative hypothesis that the first subgroup has a lower median than the second sub-group, we have to apply a non-parametric test, which does not require the assumption that the differences between the two samples are normally distributed and the variances are equal:

$$H_0 : \text{med}\left(\{y_{t,i}\}_{t=1}^{T/2}\right) \geq \text{med}\left(\{y_{t,i}\}_{t=T/2+1}^T\right),$$

$$H_1 : \text{med}\left(\{y_{t,i}\}_{t=1}^{T/2}\right) < \text{med}\left(\{y_{t,i}\}_{t=T/2+1}^T\right).$$

The Mann-Whitney test<sup>49</sup> is one of the most powerful of the non-parametric tests and it is considerably more powerful than the usual parametric tests when applied to non-normally distributed data sets. A rejection of the null hypothesis leads to the conclusion that the

<sup>48</sup> Of course, samples of unequal sizes can also be used, as long as there are no major differences in the sample sizes.

<sup>49</sup> For more details about the Mann-Whitney test see Sheskin (2003).

liquidity levels of SEAQ were lower than those of SETS.<sup>50</sup> Of course, we expect a less frequent rejection of the null hypothesis when the turnover ratio is used as the trading volume measure. According to the results presented in Table 1, in the case of the FTSE100 index, the null hypothesis is rejected at any level of significance, indicating that the median of trading volume is greater in the post-SETS period, irrespectively, of which measure of trading activity is used.

INSERT TABLE 1 ABOUT HERE

In the sequel, the hypothesis is tested separately for each of the seventy stocks and the three measures of trading volume. Tables that present the median values of trading volume measures in the pre-SETS and post-SETS samples, the Mann-Whitney statistics and the relative p-values for each of the three measures are available upon request by the authors. In the case of the volume-based turnover, from the total of the seventy stocks, only in five cases the null hypothesis is not rejected. As regards the BG Group, British American Tobacco, Foreign and Colonial and Hanson stocks their pre-SETS medians of trading volume are statistically greater than their post-SETS medians, while in the case of the Rexam stock the median of turnover volume in the pre-SETS period is not statistically lower than the median in the post-SETS period.

As regards value-based turnover, in sixty seven of the seventy cases the post-SETS median of trading volume is greater than the pre-SETS median. For any level of significance, the null hypothesis is rejected for all the cases but for the Hanson, Rexam, and Tomkins stocks. However, that measure of trading volume suffers from subjectivity as it is highly related to the current conditions of the market. For example, in the case of a ‘bull’ market, where a sudden increase of stock prices is often observed, the increase in value-based turnover is an immediate consequence. Note that the period of 1998 and 1999 is a period of abrupt increase of market prices.

When the ratio of the value-based turnover to the market value is used to measure trading volume, the null hypothesis is not rejected at 1% level of significance, for twenty of the seventy stocks. However, even this measure of trading activity, which is proved

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<sup>50</sup> Various rank-based nonparametric tests of the hypothesis, namely, that the subgroups have the same median, against the alternative that at least one subgroup has a different median, without the need to assume that distributions have to be normal and the variances have to be equal, may be found in Conover (1980).



robust to market changes, is statistically greater after Monday, October 20, 1997, in the 71% of the cases, at any reasonable level of significance.

#### 4.4. *Isolating the Effect of SETS on Trading Volume from Exogenous to Market Transparency Events*

Undoubtedly, overall trading volume is greater in the post-SETS sample. But, is the observed increase on the level of trading volume attributable to the replacement of the LSE's trading system, or was it affected by exogenous to this replacement events? To answer this question we should take into consideration the effect of events that are independent to the discussed change. For example, during the surveyed period financial markets experienced the impact of technological revolution which radically transformed trading infrastructure, especially trade execution mechanisms, the speed of dissemination and amplification of market information, and investors' and traders' access, *e.g.*, trading on the Internet by retail investor. The latter led to a very significant increase in the number of investors who actively traded on developed securities markets in the post-1997 period. In addition, from 1997 to 1999 securities markets in most of the Western world experienced one of the strongest bull markets in their history, which resulted in the creation of multiple 'stock market bubbles'. This bull market was followed by a bear market, which lasted until the end of the period covered by the sample. Thus, in order to take into consideration events exogenous to the introduction of SETS, we introduce two alternative analysis approaches.

#### 4.5. *A Deterministic Isolation of Long-Term Trading volume*

##### 4.5.1 *The First Approach*

In the first approach, we use alternative criteria to measure trading volume by subtracting the long-term trading volume that is present on both sub-samples. Using a regression model we remove the upward trend, which is present on the whole sample. Thereinafter, we test whether the remaining trading volume differs prior to and after the introduction of SETS. Let us consider that trading volume is expressed by a non-linear function of time,  $f(t)$ , and the unpredictable component,  $\varepsilon_{t,i}$ . As the trading volume, as presented in Figure 1, has an upward trend of quadratic form, we assume that  $f(t) = a_0 + a_1t + a_2t^2$ . Note that  $f(t)$  is a common factor for both the pre-sample and post-sample periods, so it

does not discriminate against either the pre-SETS or the post-SETS period. Based on the three measures of trading activity, mentioned in the previous section, we define the de-trended trading volume measures  $\varepsilon_{1,t,i}$ ,  $\varepsilon_{2,t,i}$  and  $\varepsilon_{3,t,i}$ , in the following forms:

De-trended volume-based turnover

$$\varepsilon_{1,t,i} = y_{t,i} - f(t), \quad (1)$$

De-trended value-based turnover

$$\varepsilon_{2,t,i} = y_{t,i} p_{t,i} - f(t), \quad (2)$$

De-trended turnover ratio

$$\varepsilon_{3,t,i} = (y_{t,i} p_{t,i}) / (Y_{t,i} p_{t,i}) - f(t). \quad (3)$$

The parameters  $a_0$ ,  $a_1$  and  $a_2$  in  $f(t)$  are estimated by the method of least squares, under the assumption that the component  $\varepsilon_{t,i}$  is normally distributed. Hence, for the case of the de-trended volume-based turnover, the estimated regression model is presented as:

$$\begin{aligned} y_{t,i} &= a_0 + a_1 t + a_2 t^2 + \varepsilon_{1,t,i}, \\ \varepsilon_{1,t,i} &\sim N(0, \sigma_{1,i}^2). \end{aligned} \quad (4)$$

The estimated process  $\{\hat{\varepsilon}_{1,t,i}\}_{t=1}^T$  is the de-trended volume-based turnover, for  $\hat{\varepsilon}_{1,t,i} = y_{t,i} - \hat{a}_0 + \hat{a}_1 t + \hat{a}_2 t^2$ , where  $\hat{a}_0$ ,  $\hat{a}_1$  and  $\hat{a}_2$  are the estimated values of the parameters in regression model (4). In the sequel, we re-examine the hypothesis that the level of trading volume changes following the introduction of SETS on 20<sup>th</sup> October 1997:

$$\begin{aligned} H_0 &: \text{med}\left(\{\hat{\varepsilon}_{1,t,i}\}_{t=1}^{T/2}\right) \leq \text{med}\left(\{\hat{\varepsilon}_{1,t,i}\}_{t=T/2+1}^T\right), \\ H_1 &: \text{med}\left(\{\hat{\varepsilon}_{1,t,i}\}_{t=1}^{T/2}\right) > \text{med}\left(\{\hat{\varepsilon}_{1,t,i}\}_{t=T/2+1}^T\right). \end{aligned} \quad (5)$$

The regression model (4) is also applied for deriving the de-trended trading volume measures defined in (2) and (3) and the hypothesis test in framework (5) is used for the de-trended value-based turnover and the de-trended turnover ratio.

The application of the model illustrated in framework (4) on FTSE100 daily returns yields the estimated parameters that are presented in Table 2. The Newey and West (1987) heteroskedasticity and autocorrelation consistent (HAC) standard errors are computed, as they are consistent estimators in the presence of both heteroskedasticity and

autocorrelation of unknown form. All the estimated parameters are statistically different to zero for any reasonable level of significance indicating the appropriateness of the quadratic form of  $f(t)$ .<sup>51</sup> Figure 3 depicts the plots of the de-trended measures of trading volume, and Figure 4 presents the relative frequency distribution histograms. The asymmetrical form of the histogram of frequency distribution and the high level of kurtosis show that the de-trended measures are still non-normally distributed. Thus, the use of a non-parametric test that is robust to the shortage of the normality assumption is as apposite here as in the previous section.

INSERT TABLE2 ABOUT HERE

INSERT FIGURE3 ABOUT HERE

INSERT FIGURE4 ABOUT HERE

We apply the hypothesis test in (5) for the  $\{\hat{\epsilon}_{1,t,FTSE100}\}$ ,  $\{\hat{\epsilon}_{2,t,FTSE100}\}$  and  $\{\hat{\epsilon}_{3,t,FTSE100}\}$  estimated processes. According to Table 3, for two of the three de-trended measures of trading volume the null hypothesis is strongly rejected, giving support to the assumption that the observed increase of trading volume is not attributable to the introduction of SETS. As regards the first of the de-trended measures the 12.356 value of the Mann-Whitney statistic leaves no room to dispute the lower level of the measure in the post-SETS period. In the case of the de-trended turnover ratio, the median values of pre-SETS and post-SETS samples are  $-0.00679$  and  $-0.13079$ , respectively and the Mann-Whitney statistic is 4.756, with a zero p-value. On the other hand, the de-trended value-based turnover tells us that the introduction of SETS did not influence the levels of trading volume. Summing up the case for the FTSE100 index, the removal of the upward trend that is common to both sub-samples permits the use de-trended criteria in the given measures of trading volume, which lead us to the conclusion that trading volume has not, in fact, increased due to the introduction of SETS. This conclusion is, of course, subject to upholding as valid our assumption that the influence of exogenous events - events not related to the change of trading system and standards of transparency - on trading volume can be measured and isolated.

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<sup>51</sup> However, when the assumption of uncorrelated, homoskedastic and normally distributed innovations is violated, the statistical inference concerning the estimated values of the parameters should be conducted very carefully.

INSERT TABLE3 ABOUT HERE

For the seventy stocks that comprise our dataset, let us proceed in testing the difference of median values of the de-trended measures of trading volume before and after the introduction of SETS. In respect of the de-trended volume-based turnover and the de-trended value-based turnover we reach to the same conclusion. The null hypothesis is rejected for sixty one and sixty seven stocks in the cases of the de-trended volume-based turnover and the de-trended value-based turnover, respectively, in 5% level of significance. However, in the case of the de-trended turnover ratio, the hypothesis tests do not give us a clear view. For thirty nine of the seventy cases the null hypothesis is rejected in 5% level of significance.

We can also express the dynamic formulation of trading volume by adding a dummy variable in the model illustrated in framework (4) to express the change of the trading volume level after the day that SETS was introduced:

$$y_t = a_0 + a_1t + a_2t^2 + a_3d_t + \varepsilon_t$$

$$\varepsilon_t \sim N(0, \sigma^2) \tag{6}$$

$$d_t = \begin{cases} 0, & \text{if } 1 \leq t \leq T/2 \\ 1, & \text{else.} \end{cases}$$

Framework (6) captures both the long-term upward quadratic trend,  $f(t) = a_1t + a_2t^2$ , and the different level of trading volume due to the introduction of SETS,  $a_0 + a_3d_t$ . Model (6) is applied to all three measures of trading volume. The estimated values of the parameters, which are presented in Table 4, are in accordance with our findings.

INSERT TABLE4 ABOUT HERE

The estimated values of parameter  $a_3$  are negative and statistically different to zero in two of the three cases, indicating that at the time of the introduction of SETS trading volume did not shift to a higher level. As regards the case of the measure of value-based turnover, the positive and statistically significant value of parameter  $a_3$  may be associated with the sudden increase of stock prices rather than with an increase of trading volume. At this point we should be reminded of the main disadvantage of the turnover by value criterion: it is based on current levels of stock prices. Thus, it reflects the rapid

increase in prices that securities markets experienced during the first three years of the post-SETS period due to the ‘stock market bubble’ and the increased demand induced by easy retail investor access. Figure 5 plots the regression lines from the application of model (6) for the de-trended measures, giving a visual perspective of our arguments. So, we conclude that a) although trading activity exhibits an upward trend during the full data set that is examined, b) the introduction of SETS by itself did not increase the level of trading volume.

INSERT FIGURE5 ABOUT HERE

#### 4.5.2 Simulated Evidence

In order to investigate whether the assumption that a change in the level of trading volume could be efficiently captured by the non-parametric Mann-Whitney test, we run a Monte Carlo simulation. We create 10000 series (each series is consisted of 10000 data) from the data generating processes:

$$y_t = a_0 + a_1 t + a_2 t^2 + \varepsilon_t$$

$$\varepsilon_t \stackrel{iid}{\sim} N(0,1) \quad (7)$$

and

$$y'_t = a'_0 + a'_1 t + a'_2 t^2 + a'_3 d_t + \varepsilon'_t$$

$$d_t = \begin{cases} 0, & \text{if } 1 \leq t \leq T/2 \\ 1, & \text{if } T/2 + 1 \leq t \leq T \end{cases} \quad (8)$$

$$\varepsilon'_t \stackrel{iid}{\sim} N(0,1).$$

The parameters are set equal to the values estimated for the FTSE100 turnover ratio,  $(a_0, a_1, a_2) = (2.38, -0.000877, 7.43E - 07)$  and  $(a'_0, a'_1, a'_2, a'_3) = (2.308, -0.000745, 7.97E - 07, -0.28027)$ . The data generating process in (7) produces samples with a quadratic upward trend, while the data generating process in (8) creates data samples with a long-term upward trend and a downward shift in the level of  $y'_t$  at time  $t = T/2$ . For each simulated series of both data generating process, the innovation series,  $\hat{\varepsilon}_t$ , of the regression model  $y_t = \hat{a}_0 + \hat{a}_1 t + \hat{a}_2 t^2 + \hat{\varepsilon}_t$ , is estimated. If the data generating process is (7) then the null hypothesis  $H_0: med(\{\hat{\varepsilon}_{t,i}\}_{t=1}^{T/2}) \leq med(\{\hat{\varepsilon}_{t,i}\}_{t=T/2+1}^T)$ , against the alternative  $H_1: med(\{\hat{\varepsilon}_{t,i}\}_{t=1}^{T/2}) > med(\{\hat{\varepsilon}_{t,i}\}_{t=T/2+1}^T)$  should not be rejected for the

$(1-a)\%$  of the cases at  $a\%$  level of significance. Accordingly, if the data generating process is (8) then the null hypothesis should be rejected for the  $(1-a)\%$  of the cases at  $a\%$  level of significance. The Mann-Whitney statistic is used for conducting the hypothesis test. Figure 6 presents the results of the simulation study. If the generating process (7) derives the data, indeed for the  $(1-a)\%$  of the cases the null hypothesis is not rejected at  $a\%$  level of significance. On the other hand, for the generated process (8), the total of the cases lead to the rejection of the null hypothesis. Hence, according to the simulated study, the procedure followed in the previous section in order to explore the relationship between higher standards of trade transparency, introduced as a result of the operation of SETS, with the observed increase in trading volume, leads to robust results for the Mann-Whitney hypothesis test. Furthermore, the simulation study was repeated for various sets of parameter values and we find out that the results were indifferent to the values of the applied parameters.

INSERT FIGURE6 ABOUT HERE

#### 4.6. *A Stochastic Isolation of Long-Term Trading volume*

In the previous section, we attempted to answer the question whether the introduction of SETS had an impact on trading volume levels in the sampled FTSE100 stocks. We used de-trended measures of liquidity, fitted estimating a quadratic time trend, and concluded that market developments other than the introduction of SETS were the most important reasons underlying the observed increase in trading volume. However, the factors that are not related to the market transparency were considered deterministically. The estimation of a deterministic time trend may not be robust for the choice of time period. In this case, had we analyzed a dataset relating to a different time period, we would have assumed another trend for long-term trading volume. Namely, an extension of the examined dataset to a more recent time period, when trading volume did not continue to rise according to a quadratic time trend, would obviously change the form of the long-term trend.

The method of stochastic time trends as developed by Harvey (1989) provides a statistical background to model the unobserved components along with the dummy variable expressing the change in the levels of market transparency. In this section, we propose a structural time series analysis that is based on the Kalman (1960, 1963)

filtering method in a state space form to estimate simultaneously the stochastic movement of the long-term trading volume and the effect of the change in transparency standards. Structural time series models provide a framework where the variable under investigation,  $y_{t,i}$ , is modeled as the sum of unobserved, but with a direct interpretation, components such as trend,  $\mu_{t,i}$ , and irregulars,  $\varepsilon_{t,i}$ :

$$\begin{aligned}
y_{t,i} &= \mu_{t,i} + ad_t + \varepsilon_{t,i}, \quad \varepsilon_{t,i} \stackrel{iid}{\sim} N(0, \sigma_{\varepsilon,i}^2) \\
\mu_{t,i} &= \mu_{t-1,i} + \beta_{t-1,i} + \eta_{t,i}, \quad \eta_{t,i} \stackrel{iid}{\sim} N(0, \sigma_{\eta,i}^2) \\
\beta_{t,i} &= \beta_{t-1,i} + \xi_{t,i}, \quad \xi_{t,i} \stackrel{iid}{\sim} N(0, \sigma_{\xi,i}^2) \\
d_t &= \begin{cases} 0, & \text{if } 1 \leq t \leq T/2 \\ 1, & \text{else.} \end{cases}
\end{aligned} \tag{9}$$

In order to focus on the impact of SETS on trading volume, a deterministic dummy,  $d_t$ , is introduced and we investigate if it is statistically significant. The stochastic property of irregulars, level of trend and slope of trend are driven by  $\sigma_{\varepsilon,i}^2$ ,  $\sigma_{\eta,i}^2$  and  $\sigma_{\xi,i}^2$ , respectively. If any of these variances is zero, the stochastic component reduces to a deterministic stationary process.

The structural time series model in (9) is estimated for the three measures of trading volume. In all the cases, the estimated variance of the slope is close to zero, indicating that the slope of trend is deterministic. The application of the structural model illustrated in (9) on FTSE100 daily returns yields the estimated parameters that are presented in Table 5. Figure 7 depicts the trend,  $\mu_{t,FTSE100}$ , and irregular,  $\varepsilon_{t,FTSE100}$ , components. The estimated values of parameter  $a$  are not statistically different to zero in all the cases, indicating that, at the time of the introduction of SETS, trading volume did not shift to a higher level.

INSERT TABLE5 ABOUT HERE

INSERT FIGURE7 ABOUT HERE

The model framework in (9) is applied for the three measures of trading volume in the seventy stocks of the sample. In the majority of the cases the null hypothesis that  $a=0$  is not rejected. Specifically, for 10% level of significance, the null hypothesis is rejected in four, seven and six cases as regards the measures of volume-based turnover, value-based

turnover and turnover ratio, respectively<sup>52</sup>. Therefore, in general terms the use of the stochastic method leads to a similar conclusion with that offered in the previous section: the introduction of SETS was not a significant contributing factor to the observed increase in trading volume for the stocks under consideration.

## **5. Conclusion**

On the basis of the three benchmarks used in this article to measure trading volume, we observe a clear increase in the level of trading activity of the sampled FTSE100 stocks in the post-SETS period. However, this result may be unrelated to any influence that increased transparency standards had on trading volume following the change of trading system and the introduction of a central order book for FTSE100 stocks. Thus, a procedure had to be devised to measure the influence of the introduction of SETS on trading volume during the examined period in isolation from that of other factors – factors that do not relate to this change. For this reason, we used two different methods that permitted us to isolate the trend in trading volume, which is common in both the pre-SETS and the post-SETS periods. In using the first method, we removed the deterministic trading volume trend that is shared by both periods. We named the modified measures: de-trended measures of trading volume. The use of the de-trended measures led us to the conclusion that the introduction of SETS did not have an appreciable impact on trading volume for the sampled FTSE100 stocks. In using the second method, we utilized a stochastic structural time series analysis technique, which allowed us to reach a similar conclusion: the introduction of SETS did not lead to any appreciable increase in trading volume for the stocks under study.

The above findings, based on properly adjusted data derived from the operation of SETS, indicate that the higher transparency standards, which MiFID imposes on equity securities trading in the EU, are an unlikely means of trading volume enhancement. The first possibility is that MiFID rules will fail to boost trading volume, an outcome that would be consistent with the findings of our study. Another possibility is that this will be followed by lower levels of liquidity in EU equity markets - a field in which further research is required. A combination of the aforementioned outcomes would harm the

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<sup>52</sup> Analytical tables for the seventy stocks are on file with the authors and available upon request.



depth and efficiency of EU equity markets. Therefore, EU law-makers must consider seriously the issues of trading volume and liquidity in drafting MiFID's Level 2 implementing measures, especially when it comes to the proper reach of the Directive's rules on the publication of small and medium size trades.

Since this article has only examined the impact of increased transparency rules on trading volume, further research is required to assess the likely and, once the Directive is implemented, actual impact of MiFID's transparency rules on the liquidity of EU equity markets using as benchmark, *inter alia*, the depth of the bid-offer spread.

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Figure 1. FTSE100 price index, volume-based turnover, value-based turnover and the ratio of the value-based turnover to the market value for the period October 22, 1992 to October 18, 2002.

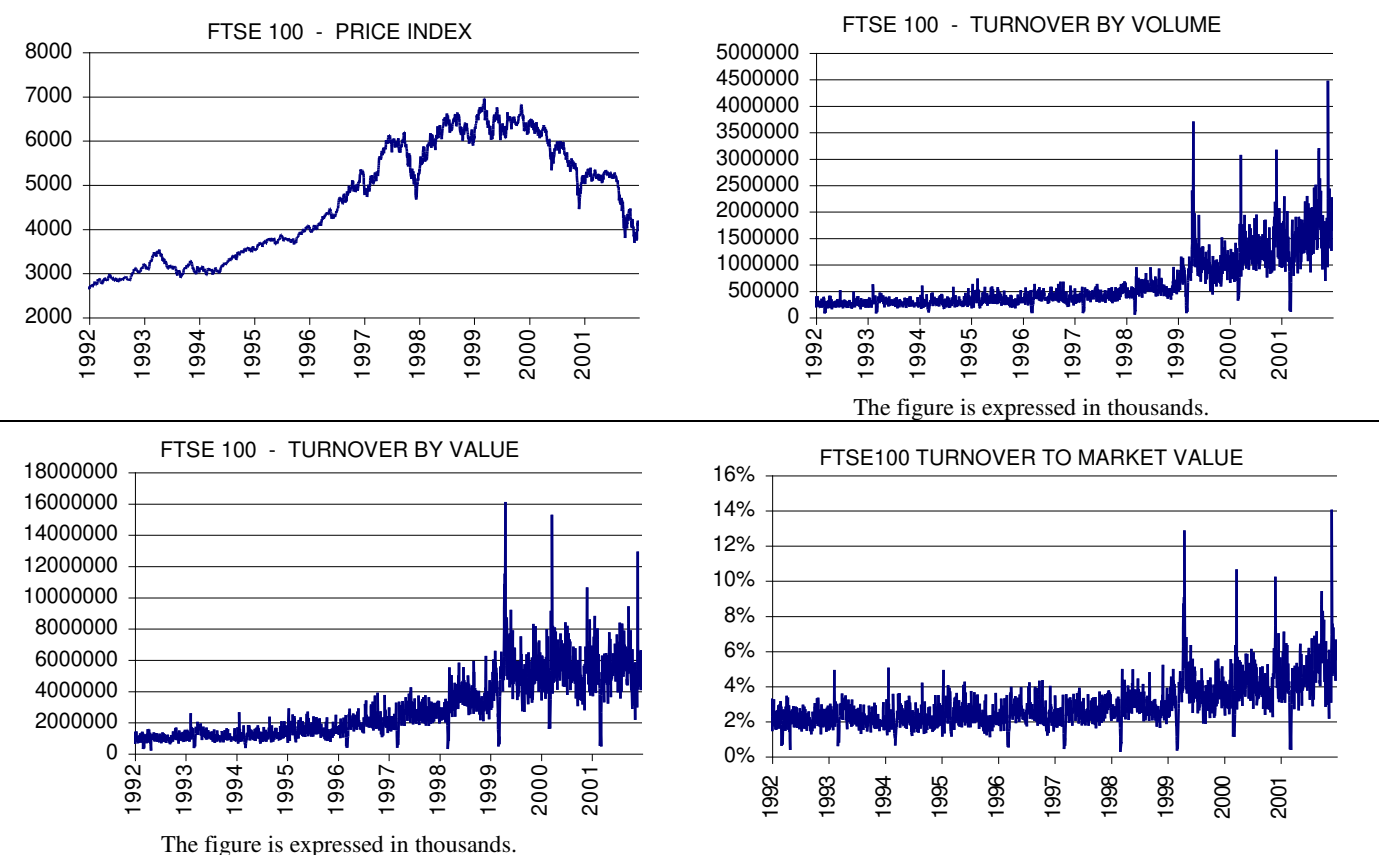


Figure 2. Histogram of the frequency distribution for the FTSE100 volume-based turnover, value-based turnover and the ratio of the value-based turnover to the market value for the period October 22, 1992 to October 18, 2002.

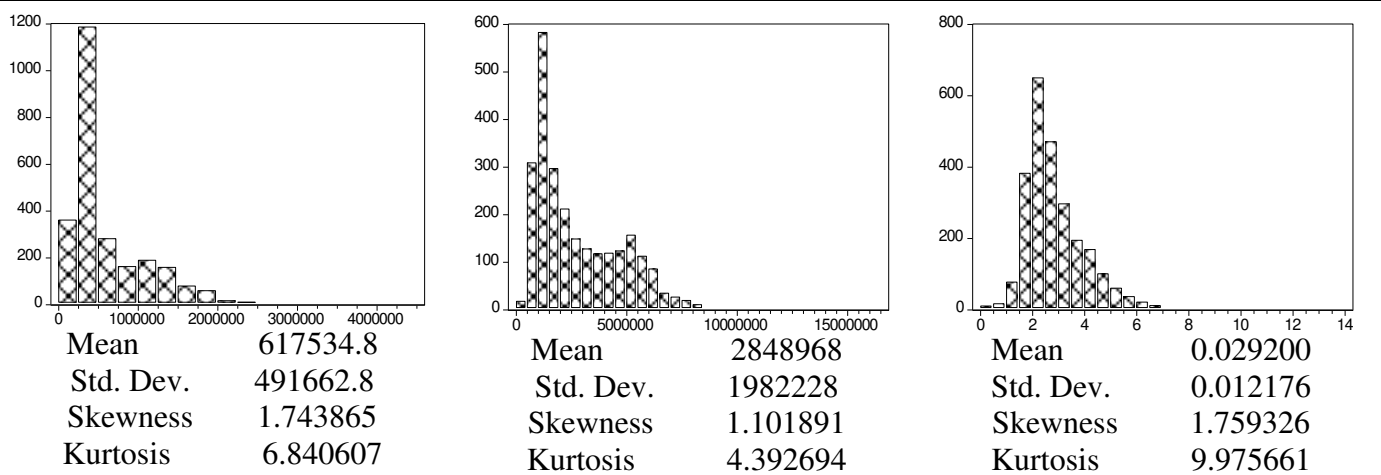
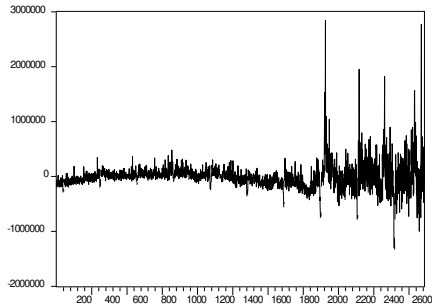
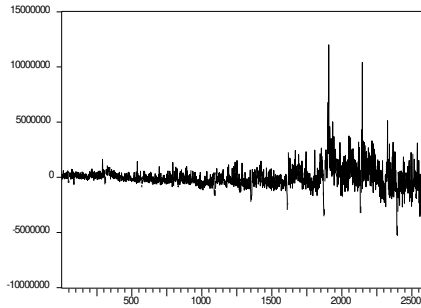


Figure 3. FTSE100 de-trended volume-based turnover, value-based turnover and turnover ratio for the period October 22, 1992 to October 18, 2002.



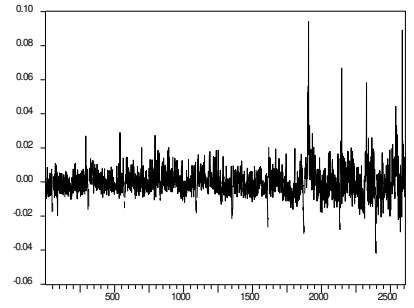
De-trended volume-based turnover

$$\{\hat{\varepsilon}_{1,t,FTSE100}\}$$



De-trended value-based turnover

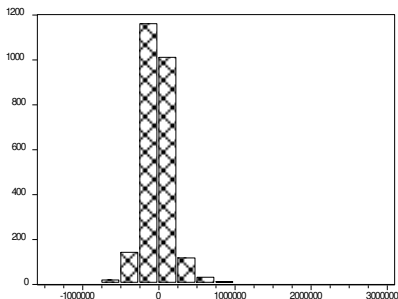
$$\{\hat{\varepsilon}_{2,t,FTSE100}\}$$



De-trended turnover ratio

$$\{\hat{\varepsilon}_{3,t,FTSE100}\}$$

Figure 4. Histogram of the frequency distribution for the FTSE100 de-trended volume-based turnover, value-based turnover and the turnover ratio for the period October 22, 1992 to October 18, 2002.



Mean 3.34E-11

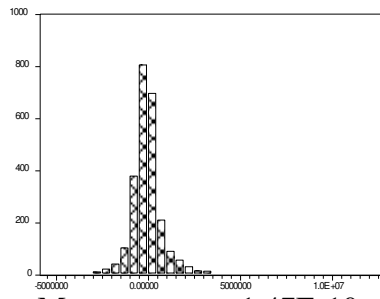
Std. Dev. 230812.5

Skewness 2.557470

Kurtosis 30.02287

De-trended volume-based turnover

$$\{\hat{\varepsilon}_{1,t,FTSE100}\}$$



Mean -1.47E-10

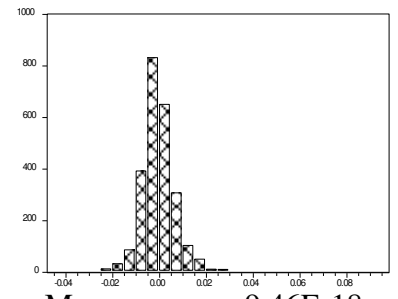
Std. Dev. 1005098.

Skewness 2.011468

Kurtosis 22.24390

De-trended value-based turnover

$$\{\hat{\varepsilon}_{2,t,FTSE100}\}$$



Mean 9.46E-18

Std. Dev. 0.008391

Skewness 1.864668

Kurtosis 20.32421

De-trended turnover ratio

$$\{\hat{\varepsilon}_{3,t,FTSE100}\}$$

Figure 5. Regression line of model (6) for the FTSE100 volume-based turnover, value-based turnover and the turnover ratio for the period October 22, 1992 to October 18, 2002.

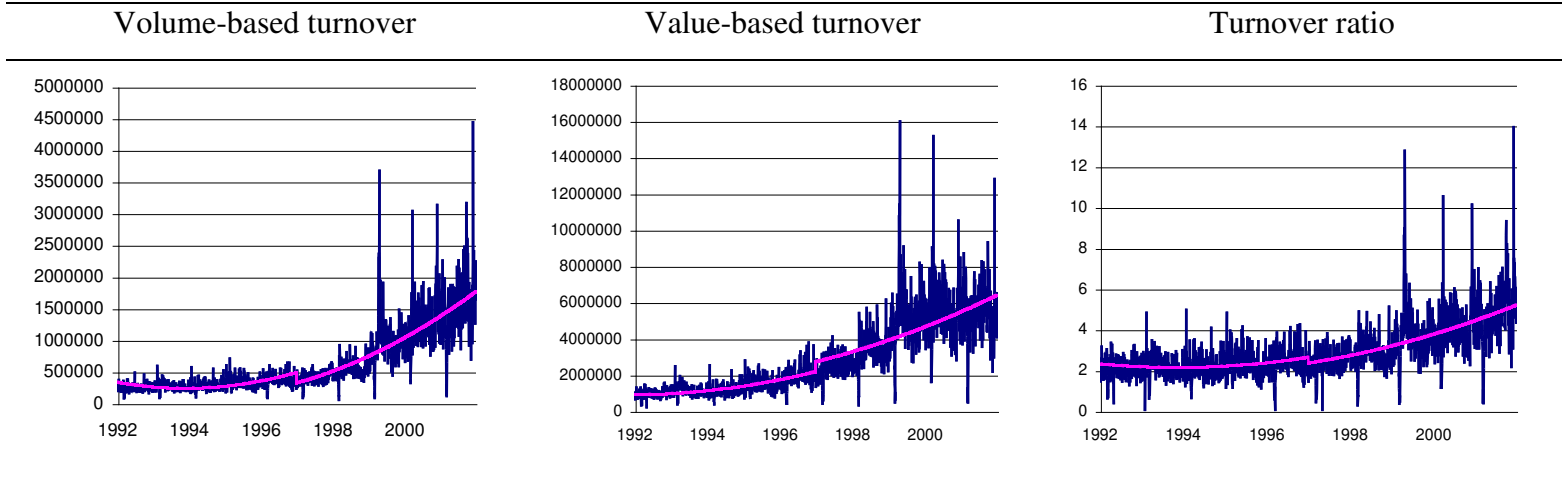


Figure 6. Frequency distribution histogram of the Mann-Whitney statistic values of the simulated series and the tabulation of the percentage counts and cumulative counts of the relative probability values. The results, that concern the data generated processes (7) and (8), are presented on the left and right panels, respectively. *I.e.*, for the data generated process (7), at  $\alpha = 5\%$  level of significance, the null hypothesis is rejected for the 5.21% of the cases. *I.e.*, for the data generated process (8), at  $\alpha = 5\%$ , the null hypothesis is rejected for the 99.61% of the cases.

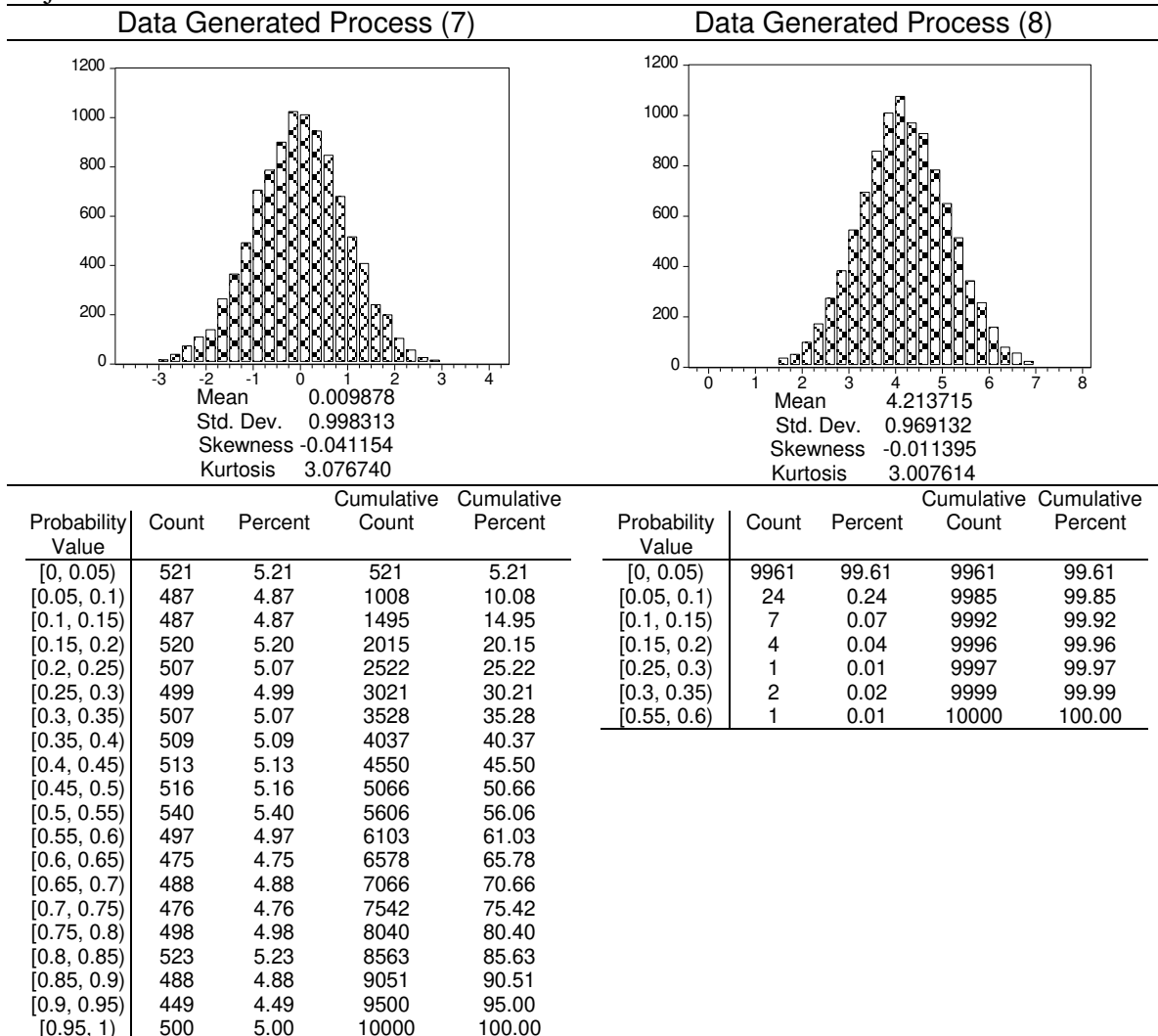




Figure 7. Trend line and Irregulars of model (9) for the FTSE100 volume-based turnover, value-based turnover and turnover ratio for the period October 22, 1992 to October 18, 2002.

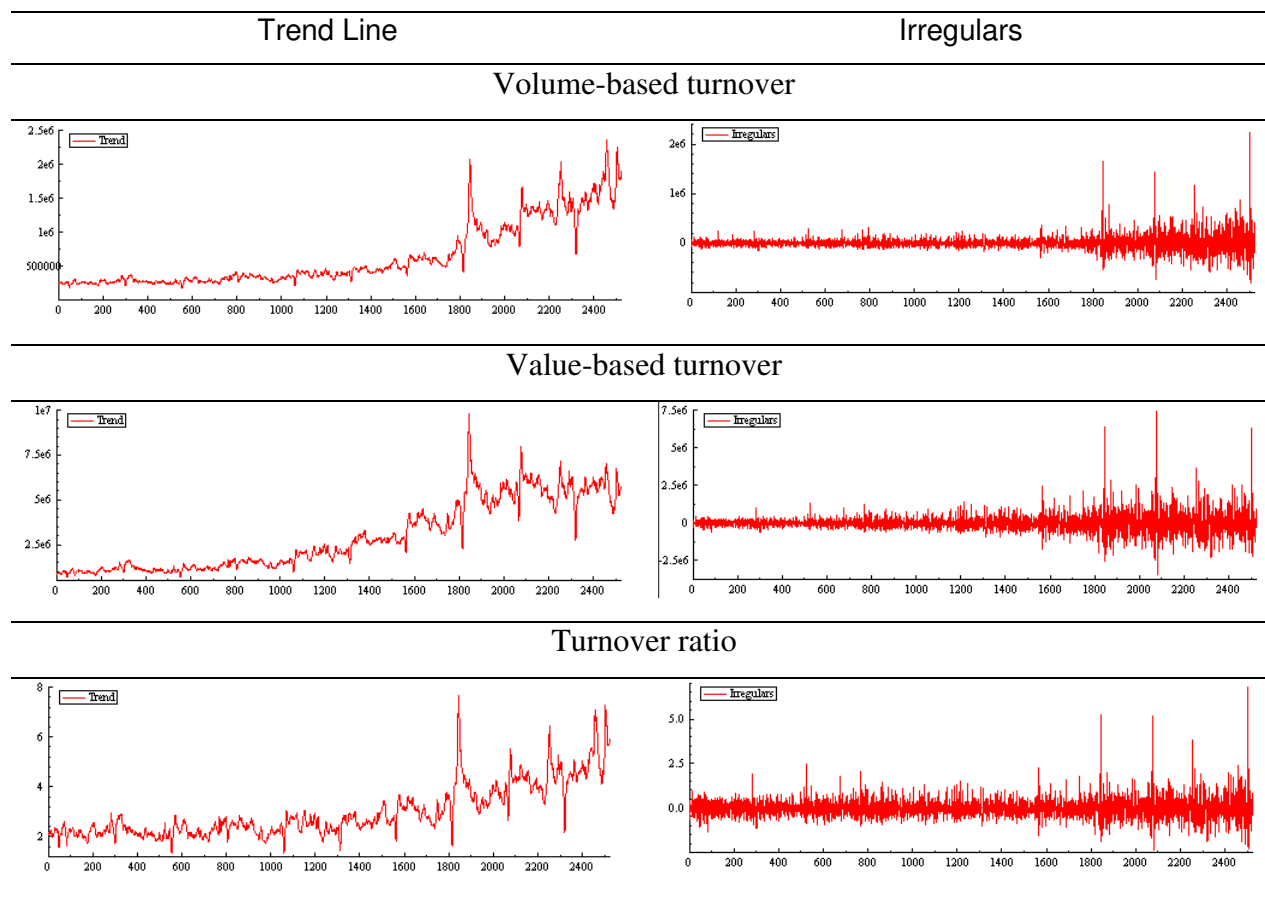


Table 1. The median values of pre-SETS and post-SETS samples, the Mann-Whitney statistics and the relative p-values for the case of the FTSE100 index. The null hypothesis that the pre-SETS median is greater than or equal to the post-SETS median against the alternative that the post-SETS period has a greater median. The null hypothesis is rejected for any level of significance.

Measure of Trading volume	Mann Whitney Statistics	Pre-SETS period median value	Post-SETS period median value	p-value
Volume-based turnover	-38.594	291501.0	850954.5	0.00
Value-based turnover	-41.183	1233874	4358136	0.00
Ratio of Turnover to Market Value	-29.824	2.21%	3.38%	0.00

Table 2. Estimated parameters of model (4) for the FTSE100 daily returns.

	De-trended volume-based turnover		De-trended value-based turnover		De-trended turnover ratio	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
$\hat{a}_0$	373052.7	27.052	758195.6	12.625	2.380	47.472
$\hat{a}_1$	-471.631	-19.299	375.3	3.525	-0.000877	-9.871
$\hat{a}_2$	0.379	41.786	0.707	17.890	7.43E-07	22.515

\* HAC standard errors are computed.

Table 3. The median values of pre-SETS and post-SETS samples, the Mann-Whitney statistics and the relative p-values for the case of the FTSE100 index. The null hypothesis that the pre-SETS median of the de-trended measure of trading volume is lower than or equal to the post-SETS median value against the alternative that the pre-SETS period has a greater median. The null hypothesis is rejected for any level of significance greater than the relative p-value.

Measure of Trading volume	Mann Whitney Statistics	Pre-SETS period median value	Post-SETS period median value	p-value
De-trended Volume-based turnover	12.356	18212.5	-63884.6	0.00
De-trended Value-based turnover	-0.474	-72668.4	-80095.9	0.68
De-trended Ratio of Turnover to Market Value	4.756	-0.00679	-0.13079	0.00

Table 4. Estimated parameters of model (6) for the FTSE100 volume-based turnover, value-based turnover and the turnover ratio for the period October 22, 1992 to October 18, 2002.

	Volume-based turnover		Value-based turnover		Turnover ratio	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
$\hat{a}_0$	330940.9	25.26774	895480.9	18.98305	2.307945	40.49612
$\hat{a}_1$	-387.2006	-11.17568	59.67590	0.446110	-0.000745	-5.451773
$\hat{a}_2$	0.404818	20.74322	0.756502	9.316662	7.96E-07	11.81935
$\hat{a}_3$	-168885.1	-6.619655	543140.6	3.989645	-0.280274	-2.730011

\* HAC standard errors are computed.

Table 5. Estimated values of model (9) for the FTSE100 volume-based turnover, value-based turnover and turnover ratio for the period October 22, 1992 to October 18, 2002.

	$\sigma_{\varepsilon, FTSE100}^2$	$\sigma_{\eta, FTSE100}^2$	Coefficient $a$	Standard Error	t-Statistic	p-value
Volume-based turnover	167000	56120	-36048	138000	-0.26143	0.7938
Value-based turnover	674000	238000	-170000	571000	-0.29777	0.7659
Turnover ratio	0.62255	0.22039	-0.10114	0.52850	-0.19137	0.8483