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# DOES MARKET ORGANIZATION SPEED UP MARKET STABILIZATION? FIRST LESSONS FROM THE BUDAPEST AND WARSAW STOCK EXCHANGES

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# ABSTRACT

## Does Market Organization Speed Up Market Stabilization? First Lessons From the Budapest and Warsaw Stock Exchanges*

This paper investigates whether different systems of financial market organization influence the way in which newly created stock markets become more (weak-form) efficient. The author conducts a detailed comparative analysis of stocks listed on the Budapest and Warsaw Stock Exchanges, 1991-8, and demonstrates that an auction market (with call trading) becomes efficient more quickly than a dealer market (with continuous trading). As an econometric tool for comparative analysis, she uses a Test for Evolving Efficiency which is a GARCH-M model with time-varying constraints.

JEL Classification: C22, G14, G15
Keywords: stock markets, learning, efficiency, transition economics

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# NON-TECHNICAL SUMMARY

Since the collapse of communism and the advent of free market economies in Central and Eastern Europe, we have witnessed the rise of an unprecedented number of new financial markets. Due to a lack of homogeneity of infrastructure and experience, each country of the region has chosen a different way to reform its financial institutions. These differences in market organization are reflected very strongly in market behaviour. In the light of that, the natural question arises: which form of market creation and regulation is optimal? It is important to answer this question, as a properly functioning financial market is crucial for macroeconomic stability and the success of market reforms.

The relative advantages of different microstructures of financial markets have been debated for a long time in the context of developed exchanges, and a clear answer to the question of whether an auction or a dealer market is better seems to be far from being found. Although the biggest and most important world stock exchanges (USA, London) are continuous dealer markets, many studies point out advantages of order-driven markets, especially if the transactions are determined by a 'call' procedure. Although the debate about the 'best' structure of developed markets has a long tradition, the problem has not arisen in the context of emerging markets. The question of how to design a new market is very important as policy-makers do not have time for experiments and the social costs of a mistake can be very high.

According to classical finance theory, a perfect market should be efficient. This means that we should not be able to earn abnormal profits based on information included in the past movement of share prices (in fact, this is a definition of weak-form efficiency). Traditional tests for (weak-form) efficiency examine whether a market was, or was not, efficient over the pre-defined period of time, for instance, ten years. In other words, such tests look at the long-run market characteristics. We cannot apply such approaches to newly created markets as those markets are undergoing dynamic transformation. It is intuitive to expect that an exchange that has operated for some years will have different properties from an exchange that has just started to operate. This can be due to better market organization, a larger number of available assets or more experienced investors. We expect a newly created market to be far from perfect but would hope to see it approaching perfection, and hence, efficiency. In this paper we use a new approach to observe changes in market efficiency: the Test for Evolving Market Efficiency. This approach allows us to see how efficiency is changing over time or, in other words, whether a market is becoming more efficient and how quickly the process is taking place.

To investigate the impact of microstructure on markets' behaviour we compare the Budapest and the Warsaw Stock Exchanges. We focus on these markets as they emerged in a similar economic environment, have a comparable length of life and are the fruit of gradual privatisation schemes (they were tiny at the moment of creation and grew as the process of privatisation accelerated). Despite all these similarities the markets differ in organization. The Budapest Stock Exchange is a dealer market with continuous trading, whereas the Warsaw Stock Exchange is an auction market with call trading. We analyse samples of ten stocks from each exchange in the period 1991-8 (April). We find that on the Warsaw Stock Exchange information was slowly incorporated into prices in the early 1990s, but, as time passed, the market became more efficient in the weak sense. Moreover, stocks which started to be listed later, when market structures were more developed, are characterised by a lower level of inefficiency than stocks which joined the Exchange earlier. In contrast, these conclusions cannot be extended to the Budapest Stock Exchange. In the case of the Hungarian stocks it is impossible to find one common trend of stabilization. The earliest-listed shares do not show any movement towards efficiency. This is also true in the case of the more recently introduced stocks.

We argue that the different levels of market transparency are responsible for this situation. The Warsaw Stock Exchange (an auction market with call-trading), being more transparent, is more 'investor-friendly', which resulted in a faster learning process. The regulations of the Exchange allowed investors to make investment decisions, submit orders, and, in effect, learn from their own experience. Moreover, a 'call' execution of buy-sell orders guaranteed that all investors had equal access to information about executed transactions. On the other hand, Hungarian investors had much less opportunity to learn. They had to rely on 'market specialists', who pushed them aside to a more passive position in the investment game. Although qualified dealers might be expected to be more rational and experienced, it is not obvious that they are in the case of an infant market. Moreover, the fact that there is a limited number of dealers can easily lead to market manipulation. In such circumstances, it is not surprising that an average Hungarian investor preferred to wait aside or look for other investment opportunities rather than invest in shares.

This means that the more transparent the system of market organization and regulation, the faster the maturing of a market, especially in the early stages of a market's life.

## 1. Introduction

Whenever there is more than one model the question arises which one is better? The relative advantages of different microstructures of financial markets have been debated for a long time and a clear answer to the question of whether an auction or a dealer market is better seems to be far from being found. Although the biggest and most important stock exchanges (USA, London) are continuous dealer markets many studies point out advantages of order-driven markets, especially if the transactions are according to a "call" procedure. In support of an auction market organisation, Pagano and Röell (1996) argue that it guarantees higher liquidity, as it is more transparent. Madhavan (1992) argues for an call - auction market which "...can function where a continuous market fails". However, a quote-driven market seems to give liquidity traders a better price than a continuous-auction system. The two systems become equivalent when there is a free entry into market making. Madhavan based his studies on a comparison of different trading systems under a problem of asymmetric information. Vogler (1997) shows that a dealer market is better only if market-makers and speculators are imperfectly competitive and delays between executing customers' orders and trading in the inter-dealer market are not large. Another argument comes from Snell and Tonks (1998) who point out that an auction market is only preferred in markets where liquidity trading is the predominant source of stock price volatility, rather than the value of competitive bidding, in reducing financial institutions "trading costs". They also argue that institutional traders who are prone to liquidity shocks might prefer a dealership structure especially on low excess volatility markets[1].

In this paper we want to look at the market-designing problem from a different perspective: instead of examining properties of developed structures we would like to see whether differences in market regimes determine the behaviour and fundamental properties of newly created markets; whether a market microstructure has an impact on the speed and the way that a market

[1]More arguments in the debate on a market microstructure can be found in papers by Biais (1993), Biais, Hillion and Spat (1995), Pagano and Roell (1992), Admati, Pfleiderer and Zechner (1994), and many others.

developments. In other words, we would like to see whether a dealer or an auction market organisation is better as an introductory market structure.

Studies of the influence of regulations on market stabilisation are very difficult to carry out due to a lack of proper samples. Purely theoretical analysis can be justified as incomplete due to simplifications coming from theoretical models. On the other hand, empirical studies are also difficult, as a comparison should be based on markets which differ in regulations, but operate in the same financial and economic environment. Moreover, we should be able to change the regulations, costlessly and immediately, to see whether there is an impact on the fundamental market properties. It would also be appropriate to look at market development when the economic situation changes, since transparency of market structures might be significant under economic and/or political uncertainty. Although, in practice, such an ideal trial is impossible, it does not mean that the research on the topic should be abandoned. In our studies of an impact of microstructure on markets' behaviour we are going to use the Budapest and Warsaw Stock Exchanges as we believe that these exchanges are the best sample for an empirical analysis. There are several arguments in support of our choice. First, both markets emerged in a similar economic environment, i.e., when Hungary and Poland were transforming their economies from central planning towards a "free market". Moreover, in both countries market reforms were successful, which might suggest a similar, in terms of speed, process of market stabilisation. Second, the market reforms had similar timing and were introduced after the period of communism which in both countries had a similar, almost 45 year history. This means that both countries had similar experiences, i.e., started the process of learning from same base. Third, both exchanges have a comparable length of life, as the Budapest Stock Exchange (BSE) was opened in June 1990, and the Warsaw Stock Exchange (WSE) in April 1991. Forth, the markets were the fruit of gradual privatisation schemes hence they were tiny at the moment of creation and grew as the process of privatisation accelerated. Despite all these similarities the markets differ in organisation. The BSE is a dealer market with continuous trading, whereas the WSE is an auction market with call trading.

To see how markets perform over time we are going to look at changes in market efficiency. The idea of looking at efficiency comes from a classical theory which states that a perfect market should be efficient. We expect a newly created market to be far from perfect but would hope to see it approaching perfection, and hence, efficiency. Through the analysis of Polish and Hungarian shares we want to answer the question of whether the process of becoming more efficient has a similar history in both exchanges. If the answer to the above question is positive it means that the market organisation is not an important factor determining the fundamental market properties at the early stage of market creation. However, if the answer is negative, i.e., there are different patterns of market behaviour observable on the exchanges, we might attribute them to differences in market microstructures. In our studies we want to examine how the efficiency of the stocks listed on the exchanges was changing over time; whether the stocks initially traded manifested a similar level of inefficiency; whether stocks joining the exchanges later started from the level of inefficiency characteristic for stocks which joined the exchange earlier when the market was supposed to be less developed. To test for changes in efficiency we are going to use a Test for Evolving Efficiency (TEE) introduced in a paper by Emerson, Hall and Zalewska-Mitura (1997) and discussed in detail by Zalewska-Mitura and Hall (1999).

The paper is organised as follows. Section 2 is an overview of the theory of market efficiency. It also presents an econometric tool, the Test for Evolving Efficiency, which will be used in the later part of the paper. Section 3 discusses the situation of European post-communist countries from a secondary-market-designing viewpoint. In Section 4 two newly created stock markets - the Budapest and Warsaw Stock Exchanges - are presented. The section contains a general description of the markets' structures, basic statistics and the data used in our studies. Section 5 presents the results of the Test for Evolving Efficiency for ten Polish and ten Hungarian stocks. Section 6 has an illustrative character, as it shows the results of the Test for Evolving Efficiency for two stocks listed on developed exchanges, the London and Paris Stock Exchanges. In Section 7, the final discussion of the results and the conclusion are presented.

## 2. Market Efficiency - Brief Overview

There are many possible ways to classify financial markets. For instance, we can distinguish classifications according to: the type of financial claims (debt investment versus equity claim), the maturity of claims (money market versus capital market), the type of issuing of securities (primary market versus secondary market) or the type of organisational structure. The *secondary market*, i.e., the market where existing financial assets are traded, may be provided with regular information about the value of securities. The periodic trading of the asset reveals to the issuer the consensus price that the asset commands in an open market. Thus firms can discover what value investors attach to their stock. Firms and noncorporate issuers can observe the prices of their bonds and the implied interest rates investors expect and demand from them. Such information helps issuers assess how well they are using the funds acquired from earlier primary market activities, and it also indicates how receptive investors would be to new offerings. The secondary market also provides the opportunity for the original buyers of the asset to reverse their investment by selling it for cash. Moreover, the secondary market offers liquidity for assets and information about the assets' fair or consensus values. It also brings together many interested parties and so can reduce the cost of searching for likely buyers and sellers of assets. Another advantage of the secondary market is that by accommodating many traders it keeps the cost of transactions low, which encourages investors to purchase financial assets.

Though secondary markets offer many kinds of assets, our further consideration will be limited to equities. There are two reasons for such a simplification. First, equities were the only listed assets when the BSE and WSE started to operate. This means that only the analyses of equities delivers information from the very first day of a market's life. Second, equities are the most frequently traded assets among assets offered on the exchanges. This means that we do not have to deal with thin trading and its impact on the fundamental properties of analysed series.

Despite all those positives, a consideration of equity markets also has its

shortcomings. This comes from the fact that equity markets are not the most significant source of raising funds, even in capitalist countries, so they might be seen as side-shows. We agree with Stiglitz(1992) that we cannot expect equity markets to "play an important role in raising funds in newly emerging democracies." However, we would like to point out that equity markets have another, maybe even more significant, part to play than rising funds during a period of economic transformation. A well-functioning financial market, and, in particular, an equity market, can be seen as an indicator of succeeding market reforms. When market reforms are successful and an economy adopts free market mechanisms, financial structures should also develop and stabilise[2]. This should lead to a growth in number of domestic and foreign investors present on the market and, in consequence, to a rise in service standards. The higher the quality of services, the more credible the financial market. Moreover, the more domestic investors are involved in the process of market creation, the more conscious society is about the market reforms undertaken. We should bear in mind that the success of market reforms is not only based on the proper decisions of authorities, but relies on its broad acceptance by society, which is the major transformation cost-bearing body. In the light of this, the wider the participation in, and therefore, understanding of, undertaken reforms, the faster the process of learning and adjustment to capitalism.

The efficiency of financial markets is primarily concerned with the availability of information in these markets. In particular, for any financial market described as efficient, information about the securities traded in the market should be accessible to market participants at a relatively low cost. In addition, the prices of traded securities should incorporate all the relevant information which can be acquired. There are two aspects of the efficiency of financial markets: *operational* and *allocational*. Operational efficiency requires that participants supplying and demanding funds are able to carry out transactions cheaply. This is satisfied when the system of financial intermediaries is sufficiently competitive, which is

[2] As it was reported by McKinnon(1973), Show(1973) and others, financial development is positively correlated with economic growth.

true in most developed financial markets. Allocational efficiency requires the prices of securities to be such that they equalise the risk-adjusted rates of return across all securities, i.e., securities with the same level of risk will offer the same expected return. In a market which is allocationally efficient, savings are allocated to productive investment in an optimal way and all participants in the market benefit.

These two types of efficiency are strongly linked. However, it is much easier to quantify and measure informational rather than operational or allocational efficiency. The term "*informational efficiency*" is related to the Efficient Market Hypothesis developed by Maurice Kendall (1953). A financial market is said to be *(informationally) efficient* if prices fully reflect all the information which is available and which is relevant to security valuation. For a market to be efficient, the requirement that prices fully reflect all available information must hold true at all times. It means that any new information must be incorporated into security prices immediately and accurately. Although there have been studies which involved explicitly or implicitly the idea of efficiency, the first formalisations of this hypothesis were introduced by Samuelson (1965) and Fama (1965). Both of these papers asserted that the difference between market expectation and market realisation is entirely random and unpredictable if the market is efficient, even though there may be some serially correlated uncertain factors in the process of realisation.

In order to make a distinction between markets which are efficient in relation to past security prices and those which are efficient in relation to other sets of information, Roberts (1967) defined three different levels of efficiency:

- *weak form efficiency* - security prices fully reflect the information contained in past price movements, i.e., they do not follow repeatable patterns and it is not possible to trade profitably purely on the basis of historical price information;

- *semistrong form efficiency* - security prices fully reflect all publicly available information, i.e., market participants cannot make superior returns by "searching out" information from publicly available sources, since the information will already be incorporated into security prices;

- *strong form efficiency* - security prices fully reflect all relevant information whether it is publicly available or not. In such a case, an investor could never earn consistently superior returns (even an insider with insider knowledge).

A great deal of research has been devoted to examining the efficiency of stock market price formation,[3] and different techniques have been developed to test for it. Although the tests for market efficiency differ from a technical point of view, they all have one common trait - they look at the long-run market characteristics. For instance, an examination of autocorrelation coefficients, variance ratio, or testing for long-range dependence allows us to test for market efficiency as a property steady over some predefined period. Such approaches do not seem to suit studies on markets which are under dynamic transformation and hence may be changing their fundamental properties. This is the case in newly created markets. In the papers Emerson et al (1997) and Zalewska-Mitura and Hall (1999) a new approach for testing for *evolving weak-form efficiency* has been proposed and discussed in detail. Using the TEE we can detect whether there were any changes in weak-form market efficiency; in other words, whether the markets were developing and maturing over time.

The version of the Test for Evolving Efficiency that we use in this paper is a GARCH-M(1,1) model with time-varying coefficients, which is given by the following set of equations:

$$r_t = \beta_{0t} + \beta_{1t} r_{t-1} + \delta h_t + e_t, \tag{1}$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2 \tag{2}$$

$$\beta_{1t} = \beta_{1(t-1)} + v_t \tag{3}$$

where $r_t$ are daily returns, error terms $e_t \sim N(0, h_t)$ and $v_t \sim NIID(0, v^2)$. The TEE differs from the classical approaches to testing for autocorrelations of returns, as it tests for *changes* in the autocorrelation coefficient of returns. The subscript $t$ appearing with the $\beta_1$ coefficient means that the coefficient can alter over time following formula (3). In other words, the TEE does not treat

[3] Most early studies are supportive of this hypothesis (e.g. Fama (1970, 1976)) , although subsequent studies have cast doubt on the universality of the phenomenon (e.g. La Porta et al (1997)).

efficiency as a market property that is steady over time, but searches for the dynamic aspects of it. More details about the TEE are presented in Appendix 1.

## 3. Emerging Markets of Central Europe

At the end of the 1980s the post-communist countries of Central Europe started to transform their economies from centrally planned to free market systems. Although they shared a common goal - a well-functioning free market economy - the paths chosen to obtain this differed from country to country. Different approaches were necessary due to different levels of economic discrepancies in the infrastructure and market experiences of the countries, and different historical and cultural traditions. They were also a consequence of the fact that the structure of capital markets differs among major capitalist economies, hence there was no unique pattern to be followed.

For instance, privatisation, which along with the creation of a capital market is one of the main vehicles for structural change, was achieved through a mass (the Czech Republic) or gradual (Hungary, Poland) share distribution scheme. The choice of privatisation methods significantly determined the way in which financial structures were created. In the Czech Republic, where the transfer of ownership from the state to private citizens was accomplished mainly through voucher privatisation, shares of 1500 enterprises were offered in one public offering, with only minimum disclosure requirements and market regulations. The government's main contribution to the development of the capital market's infrastructure was to create a system where ownership of shares was recorded in a central, computerised share registry. The government adopted a hands-off approach to regulation and allowed the various markets and exchanges to compete with each other. Furthermore, the government has ensured that only the prices of large transactions made outside the organised exchanges be publicly disclosed. In contrast, in Hungary and Poland the creation of a capital market and privatisation were introduced as an integrated process. Offering shares of medium and large-sized companies to the public through the stock market was the main method of privatisation. Regulation of public offering and trading on the secondary market closely imitated Western standards. Transparency and prudent

behaviour were the primary objectives in designing the privatisation programme and the secondary trading market.

Although the method of privatisation determines the creation of a financial market, policy makers can feel free in their choice of organisation of a secondary trading market. First, they can choose between "*order-driven*" or "*quote-driven*" models. In an "*order-driven*" market, also called an "*auction market*", market participants disclose their orders to buy or sell at specific prices, whereas in "*quote-driven*" markets, also called "*dealer*" markets, market-makers compete for orders by publishing *bid* (buy) prices and *ask* (sell) prices. The major advantage of a quote-driven market seems be the fact that only a narrow group of specialists is involved in the market creation process. The market-makers or dealers are expected to be more rational in making decisions than average, inexperienced investors. This could be important in the case of emerging markets. On the other hand, in a quote-driven market, it is impossible for all orders to interact, which is a crucial disadvantage of the system. This argument is particularly significant in emerging markets which are thin and easily manipulated. Moreover, brokers may not have adequate capital to act as dealers or market-makers, which may lead to them holding small inventories of shares. In the case of economies in transition, which are characterised by high uncertainty and risk, an order-driven market, controlled by official authorities such as the government, is more regulated, and hence more transparent to average investors.

Less obvious for the Central European countries seems to be the choice between a "*call market*" and a "*continuous market*". In a call market, buy- and sell-orders are accumulated over a specific period and executed simultaneously when market-clearing prices are established. In the continuous market, orders can be executed whenever the buy-order price exceeds the sell-order price. The main advantages to countries in transition in using a call market are its simplicity of price discovery and the ease of disseminating information to investors. These are very important, especially during the first stage of creating a financial market, when market participants are less experienced and a market is vulnerable to abuse and manipulation.

On the other hand, a continuous market better reflects current (minute to minute) market conditions because it allows investors to learn and adjust to current market conditions from the observation of incoming orders, ask and bid quotations, and the price and volume of transactions. Moreover, it also guarantees the execution of orders at the market price and implementation without delays. Hence, the choice of a market system can be seen as a choice between immediacy of trade and price stability, with the latter being crucial in the countries of the region.

In the light of such different approaches, evaluating different methods of market organisation is vital, especially since a properly functioning financial market is crucial for the macroeconomic stability and performance of market reforms. Moreover, a properly functioning financial market itself can be considered an indicator of the level of economic transformation. We should also bear in mind that a mistake in designing a market structure can have long-run consequences and may not be easily and costlessly undone. Hence, understanding whether and how a market organisation determines market behaviour and underlying properties is extremely important.

## 4. Short Tour Through Exchanges

In this section we present two newly emerged stock exchanges of Hungary and Poland. We outline the historical backgrounds and the performance of the markets since the early 1990's when the markets started to operate. More details about the markets' regulations can be found in Appendices 2 and 3.

### 4.1 The Budapest Stock Exchange

Hungary was the first country of the post-Soviet block to reform its financial system. In 1986 a two-tier banking system was introduced with the domestic commercial banking operations of the National Bank of Hungary and the State Development Bank taken over by three new commercial banks[4]. These banks inherited the loans and deposits of their predecessors. The Foreign Trade Bank was also allowed to provide commercial banking services. In 1988-89, banks

[4]The commercial banks were still owned by the state and state enterprises.

were granted additional rights to provide foreign exchange related services to their clients. With the creation of the two-tier banking system, the National Bank of Hungary gradually shifted from the direct credit ceiling to the use of indirect monetary instruments. The next step was the establishment of the law on commercial banks, which was adopted in January 1992, imposing the Basle-defined standard for capital adequacy on Hungarian Banks. Simultaneously with the changes in organisation of the financial structures the idea of creating the Budapest Stock Exchange, following the Anglo-Saxon pattern, was introduced. During the first trading session on 21 June 1990, 42 Members (i.e., 19 commercial banks and 23 brokers) traded shares of just one company (*Ibusz Rt.*). The next day, shares of *Konzum Kereskedel Rt.* joined the Exchange. In December 1990 there were 6 listed stocks and one year later, in December 1991, 20 stocks. At the beginning of April 1998, 54 stocks were on public offer. More detailed statistics can be found in Table 1. Information about the trading procedures of the BSE can be found in Appendix 2.

| | *1990* | *1991* | *1992* | *1993* | *1994* | *1995* | *1996* | *1997* |
|---|---|---|---|---|---|---|---|---|
| *No. of Equities** | 6 | 20 | 23 | 28 | 40 | 42 | 45 | 49 |
| *Capitalisation** *(USDm)* | 266.9 | 505.2 | 562.1 | 811.3 | 1,639.7 | 2,350.2 | 5,582.9 | 16,010.1 |
| *No. of transactions* | 4,255 | 13,637 | 6,715 | 14,283 | 57,854 | 60,851 | 153,937 | 478,236 |
| *Average daily number of transactions* | 24 | 54 | 27 | 57 | 230 | 244 | 620 | 1,936 |
| *BUX(market index)** | - | 837.6 | 890.9 | 1,264.15 | 1,470.1 | 1,528.3 | 4,134.31 | 6,652.84(Nov) |
| *BUX(% change)* | - | -16.2** | 6.3 | 41.9 | 16.3 | 3.9 | 170.5 | 60.9 |

Table 1. Main figures for equity trading on the Budapest Stock Exchange for the 1990-1997 period(*end of period, **calculated according to the introductory value of 1000 on 02 January 1991).

For empirical analysis we use the stocks which have the longest history and are most frequently traded as we do not intend to deal with the thin trading problem[5]. Out of 54 stocks available on the BSE in spring 1998 we selected a sample of ten. Almost all of the stocks which had been introduced to the Exchange at the

[5]Zalewska-Mitura (1998) provides several methods for an estimation of unobserved prices resulting from thin trading, using state-space representation and the Kalman Filter technique. The impact of the estimations on the results of the TEE is also discussed.

beginning of the 1990s suffered from thin trading for at least a couple of years. In addition, most well-traded stocks had short, or very short, price-histories of 2-3 years. Thin trading observed on the BSE can have different sources. In the early 1990s it was caused by the low interest of potential investors, as well as market regulations which allowed some transactions to be done outside the official market. Subsequently, however, the popularity of some stocks increased whereas that of others did not. For instance, shares of *GarAgent, Bonbon Hemingway* or *Nitroil* have remained highly illiquid since they joined the BSE. The reason for this could be their poor economic results and/or a very small free-float (for instance, only 0.2% of all Nitroil's shares are publicly listed)[6].

| *Shares* | *1st listing session* | *Number of data points* | *Capitalisation (USDm)* | *Profile* |
|---|---|---|---|---|
| *Danubius Hotel and SPA RT.* | 23.12.92 | 1,336 | 524 | four- and five-star hotels for health tourism |
| *Domus Kereskedelmi Reszvenytarsasag* | 28.12.93 | 1,085 | 8 | home & office furniture retail and wholesale |
| *Egis Pharmaceuticals Plc* | 25.07.94 | 941 | 35 | pharmaceutical company |
| *Fotex First American-Hungarian Photo Servicing* | 13.11.90 (02.01.91) | 1,835 | 181 | holding company (goods and services) |
| *Gardenia Lace Curtain Factory Plc* | 14.04.97 (09.05.97) | 243 | 21 | manufacturing and distribution of curtains |
| *Globus Canning Industry Plc* | 27.12.93 | 1,084 | 16 | manufacture of preserved food, condiments, juices |
| *Pannon-Flax Gyori Lenszovo Reszvenytarsasag* | 17.06.91 | 1,720 | 9 | linen-weaving company |
| *Pick Szeged Salami Factory and Meat Processing Co.* | 21.12.92 | 1,338 | 440 | trader of agricultural products |
| *Primagaz Hungaria Industrial Commercial Co.* | 23.12.93 | 1,085 | 357 | distribution of liquefied petroleum & in cylinders |
| *Zalekaramia Limited* | 01.08.91 | 1,687 | 283 | production of floor tiles and sanitary ware |

Table 2. General information about selected companies listed on the BSE. Dates in brackets refer to days of first observations if different from days of list listing.

[6]For more detailed discussion see Zalewska-Mitura and Hall (1998).

Finally, we chose three stocks (*Danubius, Pannon-Flax* and *Zalekaramia*) which exhibited thin trading at the beginning of their listed period, but have share price series which are long enough to provide information about the learning processes taking place on the BSE. We also selected the recently introduced shares of *Gardenia* which started to be listed in April 1997. All the series refer to daily average prices and finish on 29th April 1998. Table 2 contains more information about the selected stocks.

### 4.2 The Warsaw Stock Exchange

Poland, like Hungary, has chosen to undergo a gradual privatisation process, and in October 1990 the first laws allowing the privatisation of the state-owned firms were passed by the new post-communist government. Among 8,500 companies reported to belong to the state, five firms (*Exbud*, *Krosno*, *Próchnik*, *Śląska Fabryka Kabli* and *Tonsil)* were privatised. They were also the first five companies listed at the first trading session of the Warsaw Stock Exchange, which, after nearly 53 years, was officially re-opened for trading on 16 April 1991 (the original Warsaw Stock Exchange was founded in 1817 and closed in 1939). Trading sessions took place only once a week until January 1993 when the number of trading days was extended to three times a week. At that time, ten new companies joined the WSE. At the beginning of 1994, there were 23 listed companies and sessions took place five times a week. By the spring of 1998, the Warsaw Stock Exchange was offering more than 150 stocks. More detailed statistics are presented in Table 3.

The Warsaw Stock Exchange is a "Lyon type" capital market which can be described as "order-driven", centralised and paperless. This system is based on the establishment of a single price for each stock by comparing buy and sell-orders submitted to the Stock Exchange by brokerage houses before each session. This method of fixing the price is similar to the French 'par casier' or German 'Einheitskurs' quotation system. In July 1996, the trading system began to be reformed in order to allow trades to be executed by continuous trading and block trading systems, in addition to the established single-price auction system. Investors intending to buy or sell securities achieve this through licensed stock-

brokers. More information about trading schemes can be found in Appendix 3.

| | *1991* | *1992* | *1993* | *1994* | *1995* | *1996* | *1997* |
|---|---|---|---|---|---|---|---|
| *SINGLE-PRICE AUCTION* | | | | | | | |
| *No. of stocks** | 9 | 16 | 21 | 36 | 53 | 66 | 96 |
| *Capitalisation* (USDm)* | 147 | 222 | 2,875 | 2,954 | 4,292 | 8,054 | 10,795 |
| *P/E ratio (average)* | 4.1 | 3.4 | 13.3 | 16.4 | 7.8 | 12.3 | 14.9 |
| *No. of orders per session* | 1,423 | 3,119 | 17,323 | 52,974 | 26,745 | 25,704 | 30,106 |
| *No. of transactions per session* | 877 | 1,233 | 9,832 | 24,594 | 7,164 | 8,074 | 9,891 |
| *WIG(market index)** | 919.1 | 1,040.7 | 12,439.0 | 7,473.1 | 7,585.9 | 14,342.8 | 14,668.0 |
| *WIG(% change)* | -8.1** | 13.2 | 1,095.3 | -39.9 | 1.5 | 89.1 | 2.2 |

Table 3. Main figures for the Warsaw Stock Exchange for the period 1991-1997 (* end of the period, ** according to the introductory value of 1000 on 16 April 1991).

There are no selection problems for the sample of stocks from the Warsaw Stock Exchange. First, the market itself is rich in stocks. Second, thin trading is not an issue. Third, *all* the share price series of stocks which joined the Exchange before 1995 were not underlying series in the high proportion. This was due to frequent application of price limits in the period 1991-1994[7]. In the context of our analysis this is very important, as "truncated" series differ from "underlying" series in fundamental ways. Although in this paper we do not intend to concentrate on the impact of the application of price limits on the fundamental properties of the underlying share price series[8] we are not going to ignore the issue. Results of the TEE estimated for the first halves of our samples, i.e., the series recorded on single-price auctions, must be discussed carefully. However, as all the series suffered from the same "disease", the potential bias in our results should be similar for all the series, which simplifies the analysis.

As in the Hungarian case, we selected ten Polish companies. Five of these were the first companies listed: the price series start on 16th April 1991. The

[7]The application of price limits was adopted as a market stabilisation mechanism for stopping too rapid a share price movement.

[8]The problem of unobserved underlying prices, their estimation, and consequences for the TEE are discussed in detail in Zalewska-Mitura(1998).

remaining five stocks joined the Exchange later, and were chosen because of their long time-series of available data. Like the Hungarian stocks, the time-series end on 29th April 1998[9]. Listing dates, market capitalisation and profiles of the stocks can be found in Table 4.

| *Shares* | *1st listing session* | *Number of data points* | *Capitalisation (USDm)* | *Profile* |
|---|---|---|---|---|
| *Exbud S.A.* | 16.04.91 | 1,305 | 530 | construction, manufacture of building components, wholesale |
| *Kable S.A.* | 16.04.91 | 1,305 | - | foreign trade specialising in construction services |
| *Krosno S.A.* | 16.04.91 | 1,305 | 90 | manufacture of glass to domestic & export markets |
| *Mostostal Warszawa S.A.* | 14.10.93 | 1,049 | 90 | assembling large constructions, machinery & production lines |
| *Okocim S.A.* | 13.02.92 | 1,258 | 418 | brewery |
| *Próchnik S.A.* | 16.04.91 | 1,305 | 17 | manufacture and distribution of men's & ladies' clothes |
| *Tonsil S.A.* | 16.04.91 | 1,305 | 26 | design, manufacture and distribution of electronics |
| *Vistula S.A.* | 30.09.93 | 1,055 | 30 | manufacture of men's clothing |
| *Wedel S.A.* | 26.11.91 | 1,266 | 917 | manufacture of chocolate, biscuits, sweets & snacks |
| *Wólczanka S.A.* | 16.07.91 | 1,293 | 33 | manufacture and distribution of clothes |

Table 4. General information about selected companies listed on the WSE.

## 5. Results of the Test for Evolving Efficiency

The general statistics and official reports from the stock exchanges show yearly improvements; a greater number of stocks were listed, the number of transactions grew, and some stocks graduated successfully to international exchanges. The graphs of daily returns (Figures 1(a)-12(a)) confirm this. The BSE trading is less thin than it was in the early 1990s. The WSE now is more equilibrated, as price limits are not applied as frequently now. But is it really better? Did the investors learn from their experience? And, in particular, on which of these

[9]Wedel's shares are the only exception, as their time-series ends on 17 April 1998. On that day Wedel's shares were withdrawn from the Exchange, as a result of a contract with PepsiCo. which became the owner of Wedel.

two exchanges, the BSE or the WSE, can investors earn higher abnormal returns using information from past price movement. In the following sections we try to answer these questions.

Figures 1(b)-20(b) show significant discrepancies in the process of learning taking place on the Polish and Hungarian exchanges, since the shapes of the time-paths of the $\beta_1$ coefficients exhibit different patterns[10].

The trend towards efficiency is easily observed on the Warsaw Stock Exchange. All the time-paths of the $\beta_1$ coefficients are tending towards zero. Moreover, the time-paths of the $\beta_1$ coefficients for the five shares which were listed since 16 April 1991 - the shares of Exbud, Kable, Krosno, Próchnik and Tonsil (Figures 11, 12, 13, 16 and 17, respectively) - start from higher values (0.2-0.3) than the time-paths estimated for the other stocks which joined the market later. This suggests that the market has improved in setting more accurate prices and in absorbing new corporate information into the prices more rapidly.

We should note that greater inefficiency coincides with frequent applications of price limits, that is, over the period 1991-1994. However, as already mentioned, the time-paths of the $\beta_1$ coefficient estimated for that period are not time-paths corresponding to the underlying price series[11]. The 'true' time-paths of the $\beta_1$ coefficients estimated for the underlying series might then be higher or lower than the estimated ones. However, it should be noted that the second halves of the graphs are estimated for series which did not suffer from censoring, so it is fair to conclude that the $\beta_1$ coefficients are insignificantly different from zero by the end of the period in question.

To sum up, the market might be more or less inefficient in the introductory period than our results show. If the market was more inefficient, a great improvement has been made, as the time paths of the autocorrelation coefficients

[10] The solid lines are estimated time-paths of the $\beta_1$ coefficient. The dotted lines refer to the 95% confidence intervals.

[11] We repeated the estimation of the $\beta_1$ coefficient for the series limited to non-intervention days, i.e. limited to prices which were not censored. Results of our estimations were very close to those for the whole series, but started at slightly lower values. They confirmed our hypothesis of market stabilisation. For reasons of conciseness we do not present the graphs.

of daily returns dropped down by the end of the period in question. On the other hand, if the beginning values of the time-paths were overestimated, and in fact the "underlying" time-paths should be closer to zero than our estimates show, the Warsaw Stock Exchange might be efficient all the time.

A totally different picture appears from the Budapest Stock Exchange. In the case of the Hungarian stocks it is impossible to find one common trend of stabilisation. Each share tells a separate story. The earliest-listed shares of Pannon-Flax (Figure 7) and Fotex (Figure 4), do not show any movement towards efficiency. This also is the case for the more recently introduced shares of Danubius (Figure 1), for which the time-path of the $\beta_1$ coefficient lacks a trend towards zero. The $\beta_1$ coefficients estimated for the shares of Pick Szeged and Primagaz (Figures 8 and 9, respectively) remain at the same level for the whole investigated period and they are significantly different from zero. The time-paths of the $\beta_1$ coefficients estimated for the shares of Domus, Gardenia, Globus and Zalekaramia are not significantly different from zero (Figures 2, 5, 6 and 10, respectively). However, only for the assets of Globus and Gardenia might we conclude that some stabilisation took place[12]. The shares of Egis (Figure 3) also manifest some tendency towards efficiency but it is a very, very slow process.

Finally, we would like to stress that the beginning of the estimated time-paths of the $\beta_1$ coefficients for the assets of Danubius, Pannon-Flax and Zalekaramia correspond to the thin trading period, so the relative efficiency seen for that period is spurious.

To complete our presentation of the results of the Test for Evolving Efficiency, in Table 5 we show estimated parameters of the GARCH processes for all the stocks. For the Hungarian stocks the influence of the component related to the past shocks is stronger than the influence we observed for the Polish assets. This also supports the hypothesis that the Warsaw Stock Exchange is more stable.

[12]The case of Gardenia is rather special, as the stock has been listed for less than one year.

| *Stocks(BSE)* | *GARCH process* | *Stocks(WSE)* | *GARCH process* |
|---|---|---|---|
| *Danubius* | $h_t = 0.00 + 0.62h_{t-1} + 0.26e^2_{t-1}$ (0.00) (0.01) (0.02) | *Exbud* | $h_t = 0.00 + 0.83h_{t-1} + 0.15e^2_{t-1}$ (0.00) (0.01) (0.19) |
| *Domus* | $h_t = 0.00 + 0.88h_{t-1} + 0.10e^2_{t-1}$ (0.00) (0.01) (0.04) | *Kable* | $h_t = 0.00 + 0.87h_{t-1} + 0.11e^2_{t-1}$ (0.00) (0.02) (0.03) |
| *Egis* | $h_t = 0.00 + 0.54h_{t-1} + 0.24e^2_{t-1}$ (0.00) (0.07) (0.02) | *Krosno* | $h_t = 0.00 + 0.82h_{t-1} + 0.14e^2_{t-1}$ (0.00) (0.02) (0.14) |
| *Fotex* | $h_t = 0.00 + 0.80h_{t-1} + 0.24e^2_{t-1}$ (0.00) (0.09) (0.04) | *Mostostal W.* | $h_t = 0.00 + 0.75h_{t-1} + 0.15e^2_{t-1}$ (0.00) (0.07) (0.11) |
| *Gardenia* | $h_t = 0.00 + 0.0003h_{t-1} + 0.009e^2_{t-1}$ (0.00) (0.009) (0.001) | *Okocim* | $h_t = 0.00 + 0.74h_{t-1} + 0.19e^2_{t-1}$ (0.00) (0.03) (0.11) |
| *Globus* | $h_t = 0.00 + 0.70h_{t-1} + 0.20e^2_{t-1}$ (0.00) (0.02) (0.07) | *Próchnik* | $h_t = 0.00 + 0.86h_{t-1} + 0.11e^2_{t-1}$ (0.00) (0.02) (0.10) |
| *Pannon-Flax* | $h_t = 0.00 + 0.57h_{t-1} + 0.30e^2_{t-1}$ (0.00) (0.03) (0.88) | *Tonsil* | $h_t = 0.00 + 0.96h_{t-1} + 0.03e^2_{t-1}$ (0.00) (0.004) (0.009) |
| *Pick Szeged* | $h_t = 0.00 + 0.74h_{t-1} + 0.28e^2_{t-1}$ (0.00) (0.01) (0.09) | *Vistula* | $h_t = 0.00 + 0.90h_{t-1} + 0.08e^2_{t-1}$ (0.00) (0.02) (0.05) |
| *Primagaz* | $h_t = 0.00 + 0.23h_{t-1} + 0.58e^2_{t-1}$ (0.00) (0.04) (0.91) | *Wedel* | $h_t = 0.00 + 0.70h_{t-1} + 0.19e^2_{t-1}$ (0.00) (0.03) (0.17) |
| *Zalekaramia* | $h_t = 0.00 + 0.21h_{t-1} + 0.14e^2_{t-1}$ (0.00) (0.05) (0.06) | *Wólczanka* | $h_t = 0.00 + 0.76h_{t-1} + 0.19e^2_{t-1}$ (0.00) (0.02) (0.13) |

Table 5. The GARCH processes estimated for the Hungarian (left column) and Polish (right column) stocks. Standard errors are shown in brackets.

## 6. The Case of Selected Western Shares

Before we proceed to the final conclusions we would like to present results of the Test for Evolving Efficiency for two stocks listed on two developed exchanges. One stock, *Marks & Spencer* is listed on the London Stock Exchange which is a dealer market, similar to the Budapest Stock Exchange. The other stock, *Financiere De Paribas* is listed on the Paris Stock Exchange which is an auction market, similar to the Warsaw Stock Exchange. Both stocks have been chosen as each is one of the most frequently traded stocks on its exchange. We consider data provided by DATASTREAM. Both samples refer to daily price movements over the period 02 January 1991 - 29 April 1998. From graphs 21 and 22 we see how the different patterns of the time-paths of the $\beta_1$ coefficients have been estimated. Both curves are horizontal lines. Both the time-paths are insignificantly different

from zero. Such results have not been received for any Hungarian nor Polish stock in question.

In Table 6 we present GARCH coefficients estimated from our model for the two discussed shares.

| *Stock(LSE)* | *GARCH process* | *Stock(PSE)* | *GARCH process* |
|---|---|---|---|
| *Marks & Spencer* | $h_t = 0.00 + 0.99h_{t-1} + 0.00e^2_{t-1}$ | *Financiere* | $h_t = 0.00 + 0.87h_{t-1} + 0.07e^2_{t-1}$ |
| | (0.00) (0.00) (0.00) | *de Paribas* | (0.00) (0.02) (0.03) |

Table 6. The GARCH processes estimated for the English (left column) and French (right column) stocks. Standard errors are shown in brackets.

## 7. Conclusions

In this paper we have analysed two emerging exchanges (the Budapest and the Warsaw Stock Exchanges) to answer the question of whether market regulations influence, and in particular speed up, the process of market stabilisation, understood here as the evolution towards market efficiency in the weak sense.

We tested this hypothesis on the ten Hungarian and ten Polish liquid stocks with the longest trading histories, using the GARCH-based Test for Evolving Efficiency. Via an analysis of changes in the autocorrelation coefficients of daily returns we researched how both the Hungarian and Polish markets performed over time, and whether an investors' learning-process took place.

We found that on the Warsaw Stock Exchange information was slowly incorporated into prices in the early 1990s, but, as time passed, the market became more efficient in the weak sense. All the time-paths of the $\beta_1$ coefficient estimated from the TEE decline towards zero so that in the mid-1990s it became increasingly difficult to predict stock returns using technical analysis. In contrast, this conclusion cannot be extended to the BSE because most of its stocks did not have $\beta_1$ coefficients tending towards zero.

It is interesting that the behaviour of the exchanges differs so much. We might expect similar paths of performance since both markets were created and developing in similar economic environments. Both countries were successful in transforming economies towards free market systems which might suggest that the exchanges should grow in a similar way. At most, we might expect the Polish

market to be a bit "delayed" compared with the Hungarian one, as Hungary started its reforms earlier, and in consequence, the BSE started to operate 10 months before the WSE. Moreover, Poland seemed to be less economically stable at the beginning of the transition period as it suffered from higher inflation, a greater decline in production, and related phenomena. Taking into account all these facts we cannot see how an analysis of the general economic situation of the countries fails to help us with understanding the slower performance of the Hungarian equity market. To understand the phenomenon we have to search for other arguments and we shall investigate the effect of markets regulations.

It is well documented that in the case of developed markets an order-driven scheme is more transparent and liquid than a quote-driven one (i.e. Pagano (1992, 1996, 1998)). This seems also to be true for infant markets.

The Warsaw Stock Exchange (an auction market with call-trading), being more transparent, was all the time more "investor-friendly", which was particularly important to new investors, who had to learn about the market before they made investment decisions. The importance of that was strongly visible in early 1990's when the Budapest Stock Exchange was offering more stocks than the WSE, and hence might seem more attractive. However, in practice the BSE was very thin, whereas the WSE was "overheated". For instance, in 1992, in Budapest, there were on average 27 transactions per session (23 listed equities), whereas in Warsaw there were 1,233 transactions with just 16 listed stocks. The argument that there are nearly 4 times as many Poles as Hungarians, hence more potential investors on the WSE, does not explain the magnitude of the discrepancy. The differing attitudes of the Hungarians and the Poles to equity market participation are strongly related to the discrepancies in the markets' microstructures. The regulations of the WSE allowed Polish investors to make investment decisions, submit orders, and, in effect, learn from their own experience. Moreover, a "call" execution of buy-sell orders guaranteed that all investors had equal access to information about executed transactions.

The Hungarians had much less opportunity to learn. They had to rely on so-called market specialists, who pushed them aside to a more passive position in

the investment game. Although qualified dealers are expected to be more rational in their financial decisions than average investors, it is not obvious that they are in the case of an infant market. In such a market the dealers are, in fact, no more experienced than the average investors[13]. Moreover, the fact that there is a limited number of dealers can easily lead to market manipulations. In such circumstances, it is not surprising that an average investor preferred to bypass the dealer system. This resulted in a poorer market stabilisation , compared with the WSE and a slow down in the process of becoming more efficient.

To sum up, on the basis of our results of the Test for Evolving Efficiency we support the hypothesis that the more transparent the system of market organisation and regulation, the faster the maturing of a market, especially in the early stages of a market's life. However, the question remains: what will the future performance of the exchanges look like?

**Appendix 1 - The Test for Evolving Efficiency**

To test for possible changes in market efficiency we need a tool which: first, will allow us to check for at least weak form efficiency, second, will be able to detect changes in efficiency as time passes, and third, will operate on a stochastic series for which the error process can have the variance changing over time in a systematic way, i.e., the error process turns out not to have a full set of NIID properties. To reach all these requirements we propose to estimate, using the Kalman Filter, the following model:

$$r_t = \beta_{0t} + \sum_{i=1}^{p} \beta_{it} r_{t-i} + \delta h_t + e_t, \quad e_t \sim N(0, h_t) \tag{A.1}$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2. \tag{A.2}$$

$$\beta_{it} = \beta_{it-1} + v_{it}, \quad i = 0, ..., p \quad v_{it} \sim N(0, \sigma_i^2). \tag{A.3}$$

The parameters required to estimate the time-paths of $\beta_{it}$, i.e., $\delta, \alpha_0, \alpha_1, \alpha_2$ and all $p$ values of $\sigma_i^2$ can be found by computing and maximising the likelihood function

[13] In order to obtain a dealer's licence for the BSE, dealers were trained on courses lasting a few months.

(Harvey(1996)).

To prove the power of the above test we propose the following Monte Carlo test.

We generate a series of 1000 autocorrelated returns which follow the formula:

$$r_t = \beta_t r_{t-1} + \varepsilon_t, \quad where\ \varepsilon_t \sim N(0, \sigma^2),$$

where the factor $\beta_t$ changes over time as follows:

$$\beta_t = \begin{cases} \frac{-0.8}{499}(t-2) + 0.8, & \text{if } t = 2, ..., 501 \\ 0, & \text{if } t = 502, ..., 1000. \end{cases} \qquad (A.4)$$

To illustrate, the coefficient $\beta_t$ starts from the value 0.8 (a market that is inefficient) and drops linearly to zero for the first 500 observations, and then remains constant at zero (a market that has become efficient).

We perform the test for three values of the variance, $\sigma^2$: 0.0005, 0.004 and 0.05. The first two values of $\sigma^2$ were taken to be close to values observed on emerging markets (the Budapest and the Warsaw Stock Exchanges, respectively). The third value of $\sigma^2$ is very large and we do not know of any stock exchange characterised by such a large variance, but to analyse the influence of the variability of returns on the precision of values estimated by our model, we decided that it would be useful to take such a large value of $\sigma^2$ into consideration. For each sequence of returns we estimate, using the Kalman Filter, all parameters required by the TEE. Hence for each sequence $\{r_t\}_{t=1}^{1000}$ we obtain the corresponding sequence of $\beta$'s. We repeat, 2,000 times[14], this procedure of generating the sequences $\{r_t\}_{t=1}^{1000}$ and, in consequence, the sequences $\{\beta_t\}_{t=2}^{1000}$ , for each value of $\sigma^2$, i.e., $\sigma^2 = 0.0005$, $= 0.004$ and $= 0.05$.

For each sequence of $\{\beta_t\}$ (let us call them $\{\beta_t^i\}_{i=1,...,2000}$) we calculate the mean and the standard deviation at each point of time $t = 2, ..., 1000$, i.e.

[14]The 10,000 replications required by Monte Carlo method were impractical due to the timing required to find the maximum of the Maximum Likelihood Function defined in the process of searching for unknown parameters from the state and measurement equations. Calculations to undertake 2,000 replications for each value of $\sigma^2$ lasted 1 month on the UNIX machine available at the London Business School.

$$\tilde{\beta}_t = \frac{1}{2000} \sum_{i=1}^{2000} \beta_t^i$$

$$\sigma_t = (\frac{1}{1999} \sum_{i=1}^{2000} (\beta_t^i - \tilde{\beta}_t)^2)^{\frac{1}{2}}.$$

In Figure A1 we present the results of the test. Since the time-paths of the means and standard deviations for the three considered values of $\sigma^2$ were the same we only present one time-path of the estimated $\beta_1$ coefficient[15]. In Figure A1(a) the continuous line is the mean $\{\tilde{\beta_t}\}$, the dotted lines are the 95% confidence intervals, i.e. $\{\tilde{\beta} \pm 2\sigma_t\}$, and the dashed line corresponds to the assumed pattern described by equation (A.4). For a more direct illustration of the differences between the assumed and estimated time-paths of the $\beta$ coefficient, see Figure A1(b). Here the continuous line shows the difference between the continuous and dashed lines presented in part (a). The dotted lines, as previously, refer to a graphical demonstration of the 95% confidence intervals.

Figures A1(a-b) prove the applicability of our method for testing for evolving efficiency. The estimated and assumed time-paths of the $\beta$'s are nearly identical. The differences are observable at the beginning of the paths estimated (we underestimate the real value), and in the middle, where the $\beta$ coefficient changes its pattern (we overestimate the real value). Nevertheless, the differences are very small, less than 0.11 and 0.03, for the initial and middle differences respectively. Moreover, they are insignificantly different from zero.

The TEE has two important properties. First, the time-path of the $\beta$'s estimated does not depend on $\sigma^2$ - the variance of the daily returns. Second, the probability of the pattern detection does not change with changes in values of $\sigma^2$.

When we applied the traditional approach, assuming that the $\beta$ coefficient was constant over time, but in fact it was changing according to formula (A.4) for the three discussed values of $\sigma^2$, we obtained that $\beta$ would be equal to 0.26 (st.

[15] The observable differences were on the fourth and later decimal places which is not significant and is related rather to numerical errors in the calculations, or to too few performed replications (only 2,000 for each $\sigma^2$).

error = 0.04). This means that the hypothetical market, introduced by us, would appear under the traditional approach to be inefficient, with a significant rate over the whole period. But that is not true as the inefficiency decreased during the first 500 days and for the next 500 days the market was efficient.

## Appendix 2 - Regulations of the Budapest Stock Exchange

The Budapest Stock Exchange is organised on the Anglo-Saxon model, hence all transactions are to be implemented on the Floor of the Stock Exchange during the opening hours by brokers authorised by the Members of the Stock Exchange. During the trading session the brokers may make bids and offers orally or in writing and may respond to the bids and offers of other brokers in accordance with the provision of the Rules of the Budapest Stock Exchange. If no trade is carried out for a given security on a given day, then the price of the last trade of the security is regarded as the closing price, which means that the closing price of the non-traded asset remains unchanged as long as non-traded period lasts.

As mechanisms to stabilise the movement of prices, breaks and suspensions of trading were introduced. A break means a suspension of trading in the given share, and therefore no bids or offers can be made for it. The temporary suspension of the sale and purchase of a given security can be ordered by the Speaker if the change in the price of shares admitted to the Stock Exchange is greater than +/-10%, but less than +/-20%, compared with the opening price. The trading break may last 5 minutes. If the change in price, compared with the opening price, is bigger than +/-20%, the break may last 5-10 minutes[16]. Moreover, the Chief Executive Officer may suspend trading in certain securities for a maximum period of three days, notifying the issuer at the same time, if s/he deems that the development of the share price or the trade execution cannot be supported by the information or facts known to the public.

In the case where it is suspected that the further trading of a given share cannot offer organised, fair and transparent trading on the Stock Exchange because of

[16] These restrictions about price limits and timing of breaks in trading were introduced in spring 1997. Before 1997, executions of transactions could be stopped for up to 10 minutes if prices were changing within 20-30%. If a security's price was changing more than 30% then the trade could be stopped for 10-20 minutes.

an irregular development in prices or trends of transactions, the Stock Exchange Board or the Supervision Board may suspend trading on that security for an indefinite period of time. Another suspension, ordered by the Chief Executive Officer, can stop trading in a certain type of security or in all the securities on the Exchange. Trading can be suspended if the Chief Executive Officer deems that continued trading would endanger the well-being of investors or the operation of the Stock Exchange. This kind of suspension can last one day.

Lastly, the Stock Exchange Board or the Supervision Board may suspend trading in certain types of securities or in overall trading on the Stock Exchange if the general financial, economic or political situation does not provide for organised and transparent trading on the Stock Exchange, and continuous and fair trading cannot be maintained. Suspension by the SE Board requires the approval of the Supervision Board if the period of the suspension exceeds three days, and the Ministry of Finance if it is longer than ten days.

In the spring of 1997 the general meeting of the BSE developed a new model for its operation. The major elements of the new model are the establishment of market segments for different instruments (sections), the extension of those entitled to trade on the stock exchange as well as changes in the voting rights of participants in the general meeting and in the structure of fees. The new act has significantly changed the principle of regulation by opening certain markets of the stock exchange to market participants - primarily banks, which had been kept at arm's length since the foundation of the BSE in 1990. Until 1997, only stock-brokers operating in company form (limited liability company or share company) were allowed to be members of the BSE and, consequently, traders. The new act relaxes this limitation allowing some non-members to participate in investment activities (but still only institutions authorised to trade in shares can be members). The new act has opened up markets in government securities and derivative products for credit institutions. Moreover, private individuals can make transactions personally (on their own account) in the derivatives market.

The new act also changed voting rights, giving members with 1-10 votes depending on their turnover per section. This means that each member may

have 1-30 votes in the calendar year preceding the convocation of the meeting[17].

The new regulation makes the fees subject to turnover and also makes a difference between members of the BSE and those who are only members of a section[18]. There are two main types of fees: entry (stock exchange/section) fees and turnover fees. The turnover fees, to be paid by both buyers and sellers, are different in the various sections but identical within one section.

## Appendix 3 - Regulations of the Warsaw Stock Exchange

### Single price-auction

The fixing of the day's price is the main role of the specialist broker who receives a list of orders qualifying for the session, then verifies them and proposes the price for a given security. In their orders, investors define the quantity and the price of securities by indicating the price limit or 'at the market '. The validity of an order cannot exceed the end of the next month. In calculating the day's price the specialist broker has to maximise turnover of the security, reach the smallest possible difference between demand and supply, and finally, minimise the difference in price between that of the current session and that of the previous one.

When the price is fixed and approved by the chairman of the session, all transactions of a given security are executed at the price. This price is an 'equilibrium price' which balances the market. All '*po kursie dnia*' (i.e., at the market price) orders, buy-orders with a higher price limit and sell-orders with a price limit lower than the day's rate, are executed. It is possible that orders are executed partially on a balanced market, but only those that have their price limit equal to the day's rate. A duty of the specialist is to execute orders in the same proportion. In this case, one estimates the market situation as buy- or sell-surplus which is indicated by letters 'nk' (i.e., surplus of buy-orders) or 'ns' (i.e., surplus of sell-orders) following the security's price on the list of quotations.

It can also happen that the price which minimises the difference between

[17] Before the spring 1997 each member had one vote at the general meeting of the BSE provided that 10% of the average trading volume was reached in the calendar year preceding the convocation of the meeting.

[18] In the old system each member paid the same fees for stock market services.

demand and supply, and minimises turnover, exceeds the lower or upper limit. Then the day's price is fixed at the highest or lowest acceptable level, i.e., it is equal to +/- 10% of the previous trading session's rate. This truncation to 10%, introduced as a mechanism for price stabilisation, means that the market is not balanced and the day's price is not an equilibrium price.

When the market is not balanced the specialist is obliged to indicate the degree of market imbalance between supply and demand at the given price. If the predominance of demand and supply is greater than 5:1 the difference is too big for transactions to be completed, and none of the orders is realised. Market participants are informed about the non-transaction price by publishing this price with letters 'ok' (i.e., buy orders limited) in the case of the predominance of buy-orders or 'os' (i.e., sell-orders limited) when sell-orders predominate. If the imbalance is smaller than 5:1, transactions can be executed, but only after every order on the predominating side of the market is proportionally reduced. In this case the price is accompanied by the letters 'rk' (i.e., buy-orders reduced) or 'rs' (i.e., sell-orders reduced).

The specialist can reduce the market imbalance by intervening, that is during the session, but after the price determination; the specialist broker may buy or sell securities on his/her own account or declare that he will buy or sell securities from other exchange members.

**Continuous trading system (CT system)**

The CT system was developed in 1992 for Treasury bonds, but on 8th July 1996 it was extended to shares. Initially, only the five shares with the highest liquidity were permitted for continuous trading, but on 12th August certified shares of the National Investment Fund (NIF) were also approved for continuous trading. In the spring of 1998, 32 stocks were traded via the continuous system.

In the CT system, transaction units consist of round lots, of sizes which are determined individually for each security, but having values around PLN 10,000(USD 4,000). The security's opening price for continuous trading cannot be higher or lower than the reference price[19] by more than 5% for bonds or 10%

[19]i.e. the price determined by the previous session's single-price auction if there was a trade, or the price of

for shares and NIF certificates. If the opening price cannot be established at the beginning of a trading session, the trading session is commenced and the first transaction price becomes the opening price. The CT session starts by identifying the best bid and ask offers.

**Block trades**

Large blocks of securities can be traded off-session when an Exchange member presents to the Exchange buy- or sell-orders for the same number of securities at the same price. The number of securities in a block trade must be at least equal to the average number of securities sold during the last three sessions. The price of securities in a block trade may differ from the last session's price by no more than 15%, when the number of securities in the block is less than 5% of the number of securities admitted for trading in that security. When the block is larger than that, the price may differ from the last session's price by no more than 30%.

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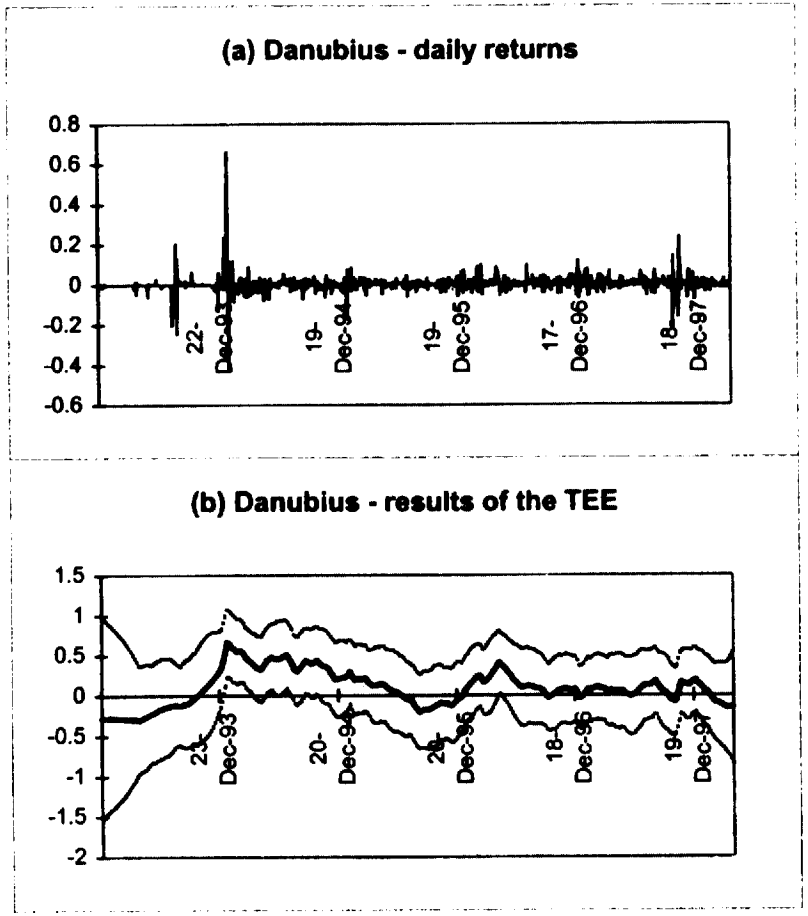


Figure 1. Daily returns and results of the TEE for the Danubius' shares.

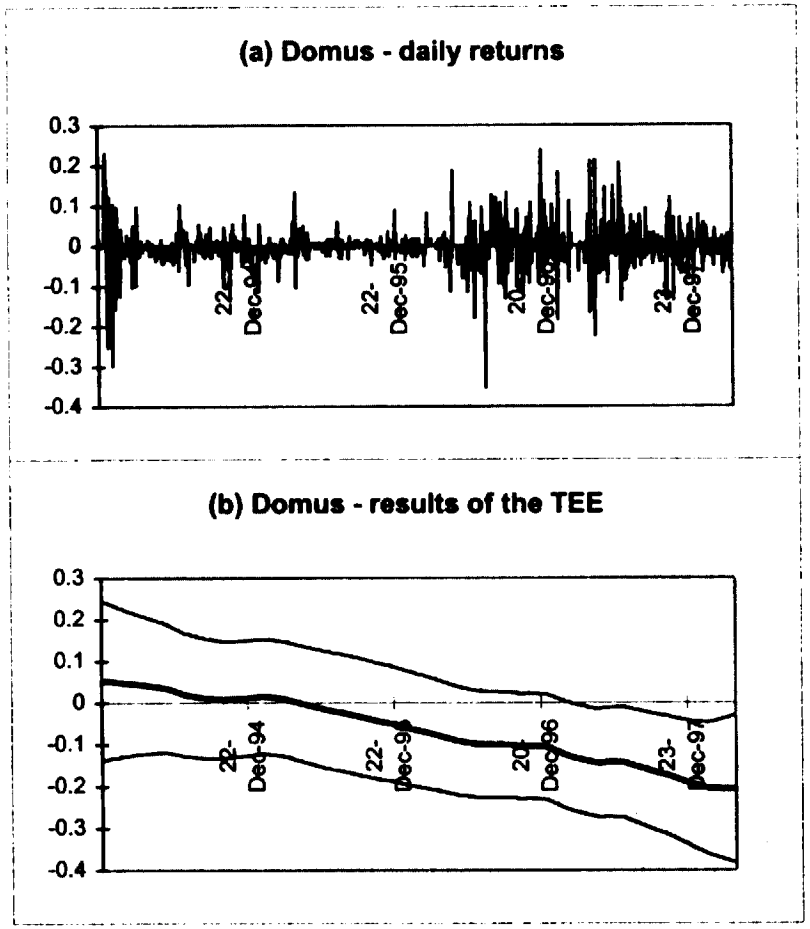


Figure 2. Daily returns and results of the TEE for the Domus' shares.

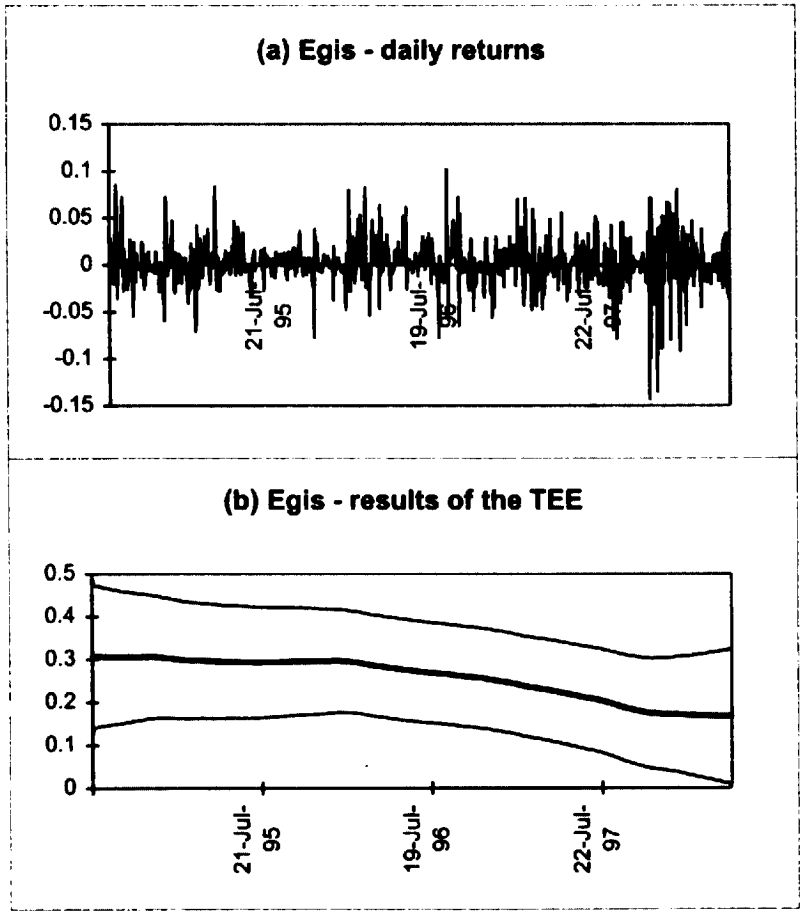


Figure 3. Daily returns and results of the TEE for the Egis' shares.

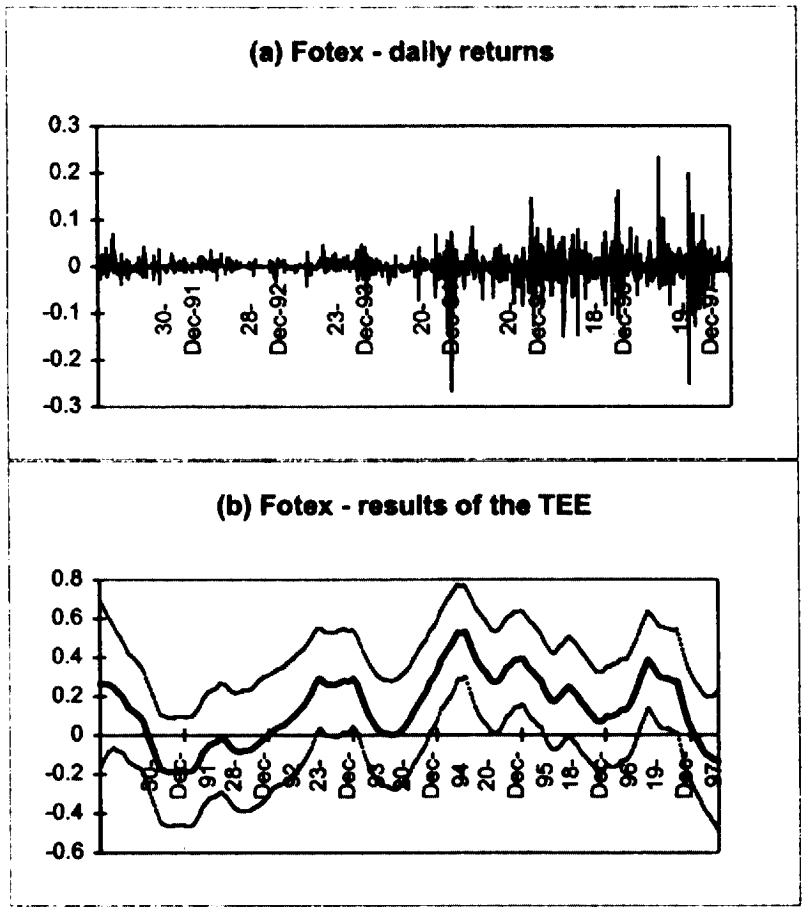


Figure 4. Daily returns and results of the TEE for the Fotex's shares.

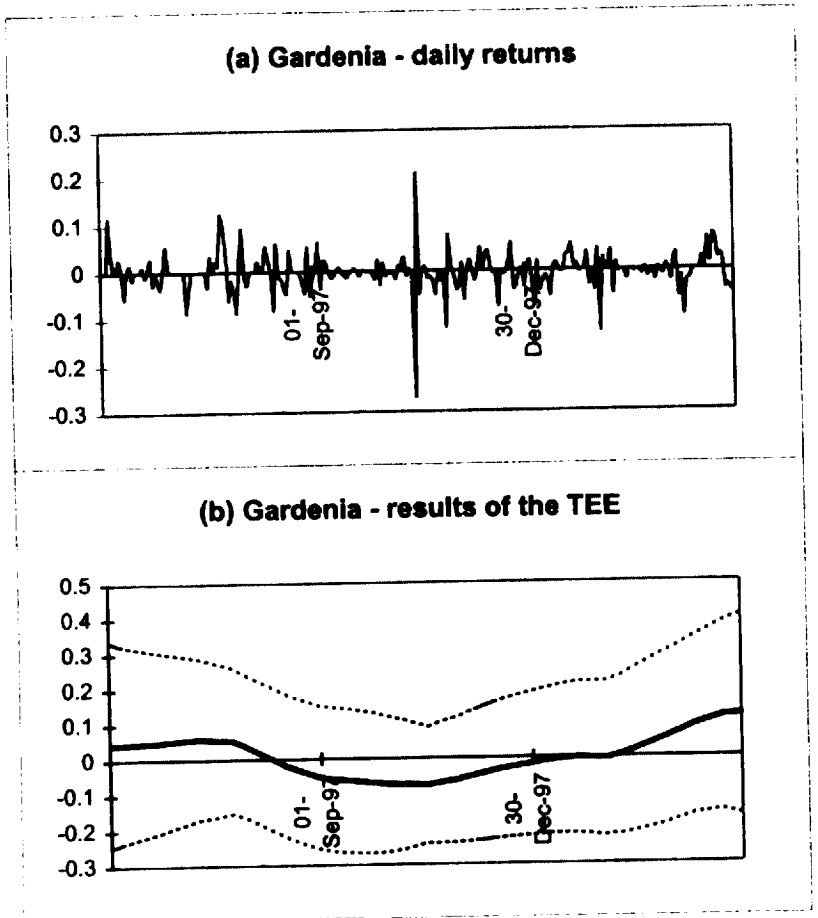


Figure 5. Daily returns and results of the TEE for the Gardenia's shares.

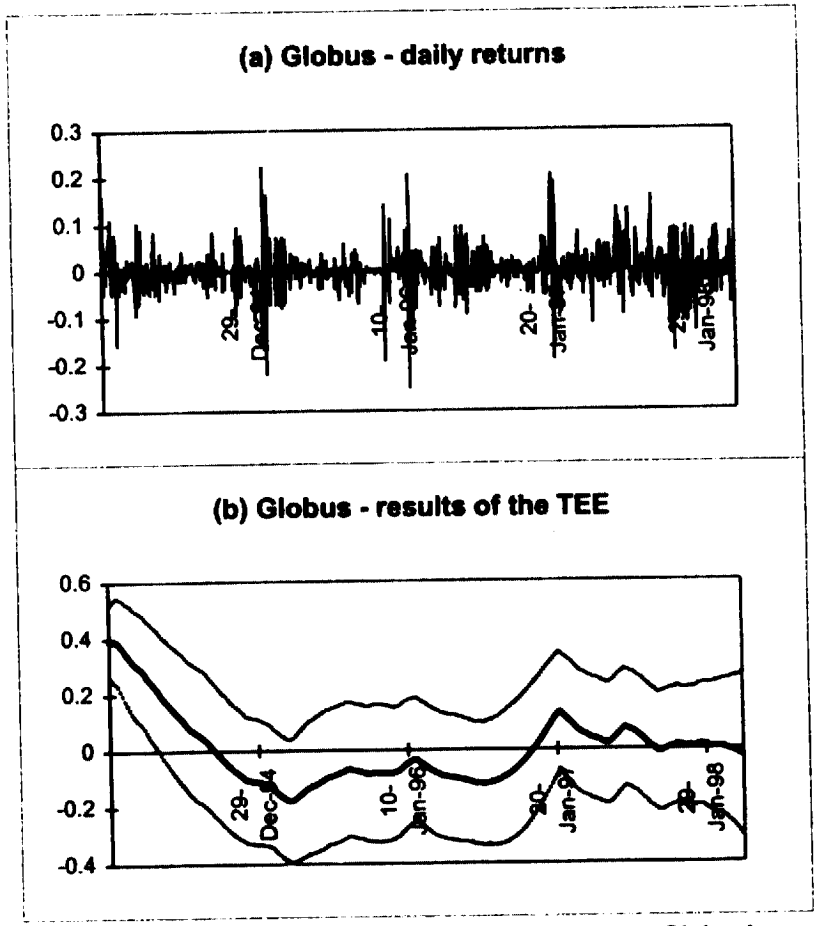


Figure 6. Daily returns and results of the TEE for the Globus' shares.

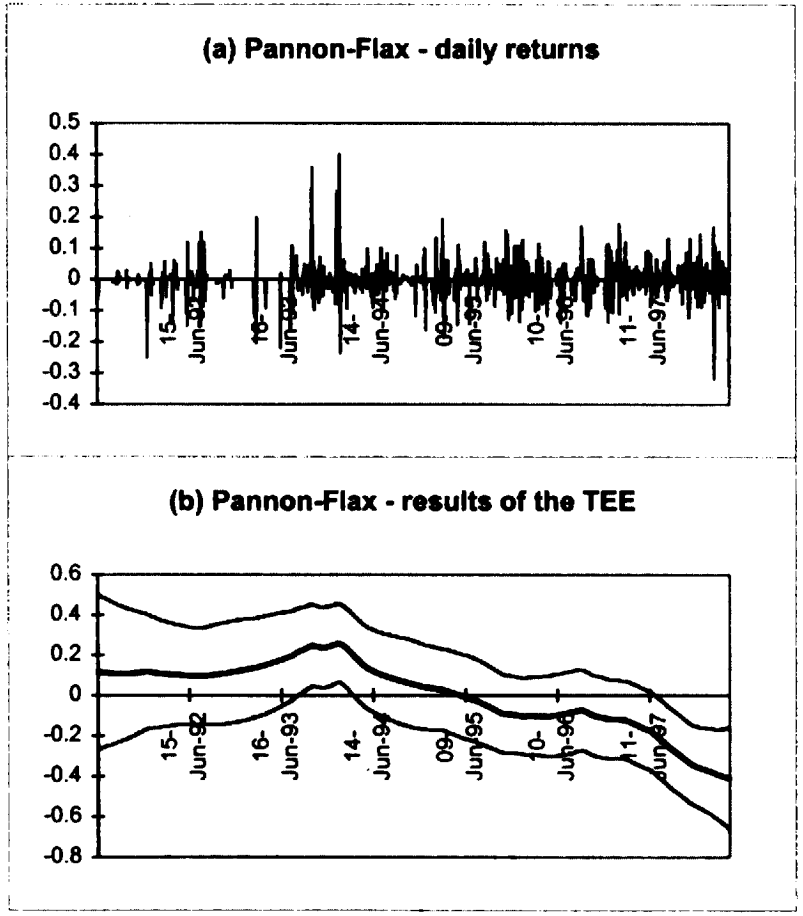


Figure 7. Daily returns and results of the TEE for the Pannon-Flax's shares.

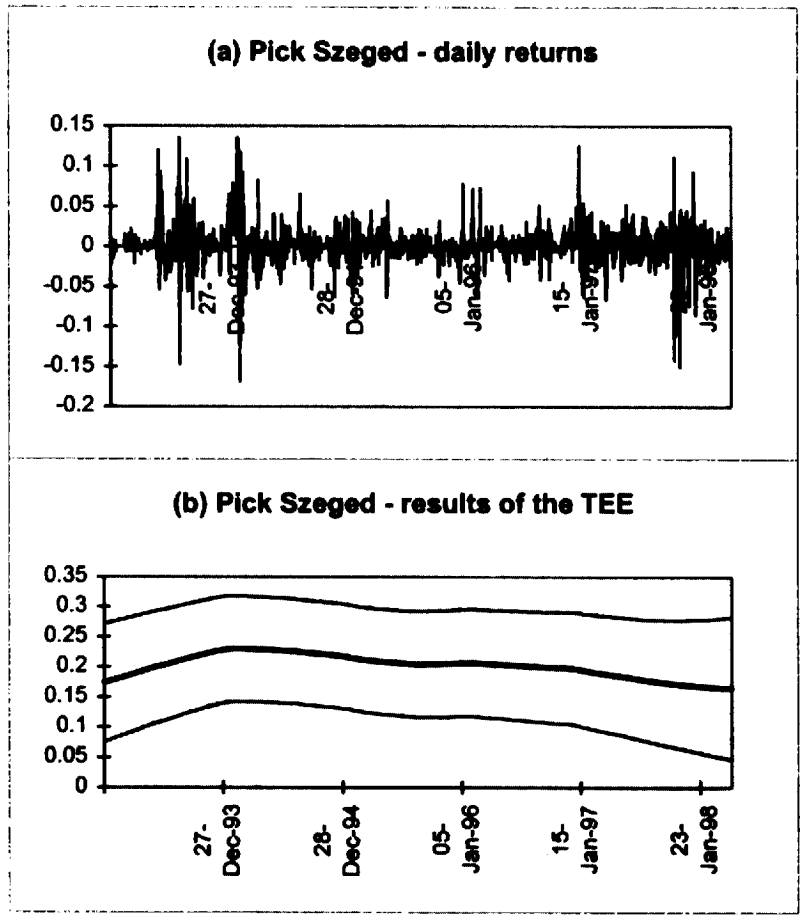


Figure 8. Daily returns and results of the TEE for the Pick Szeged's shares.

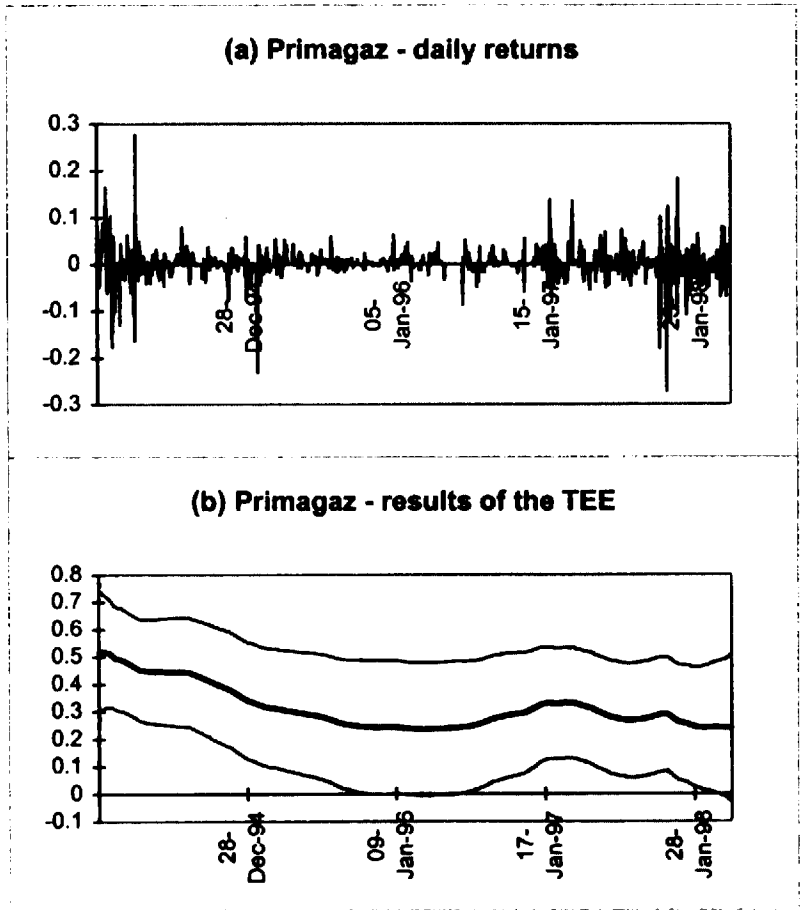


Figure 9. Daily returns and results of the TEE for the Primagaz's shares.

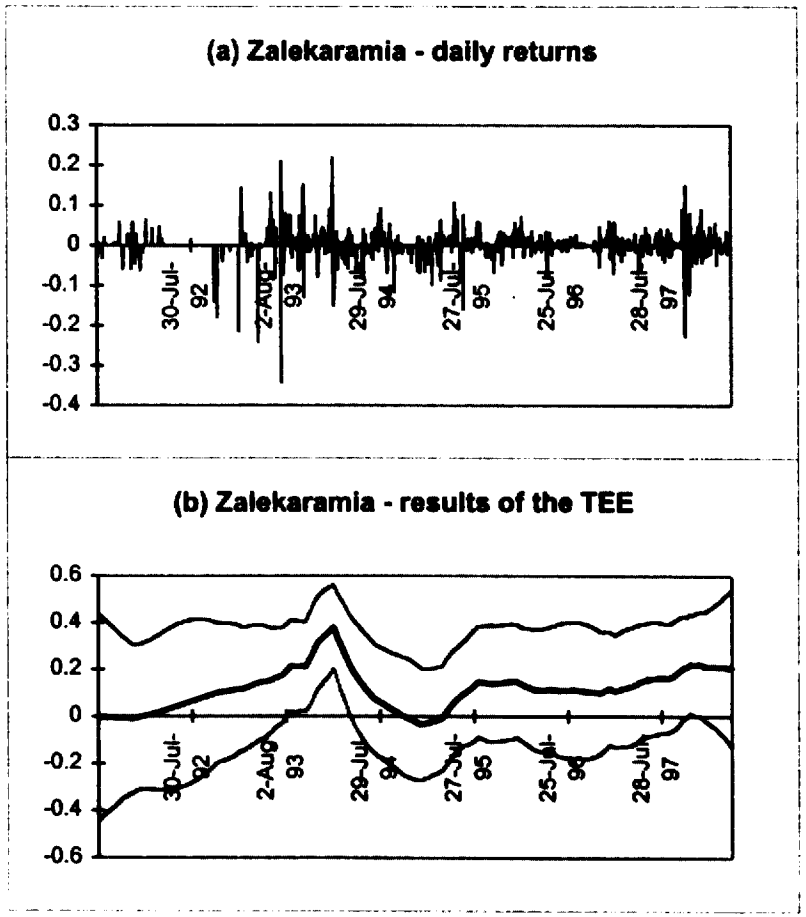


Figure 10. Daily returns and results of the TEE for the Zalekaramia's shares.

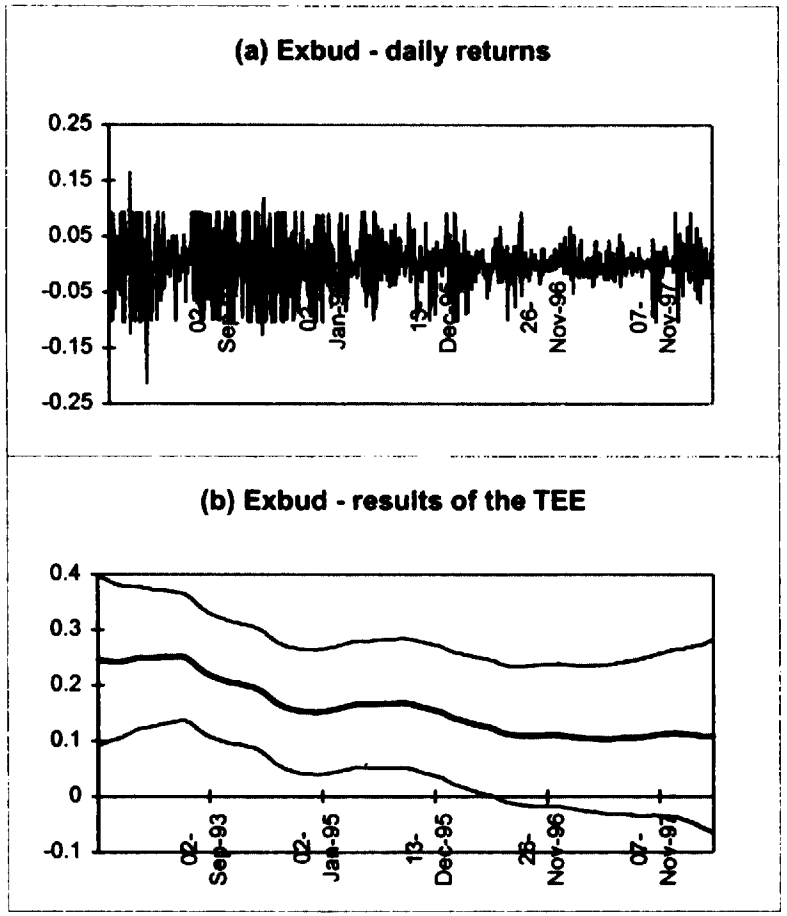


Figure 11. Daily returns and results of the TEE for the Exbud's shares.

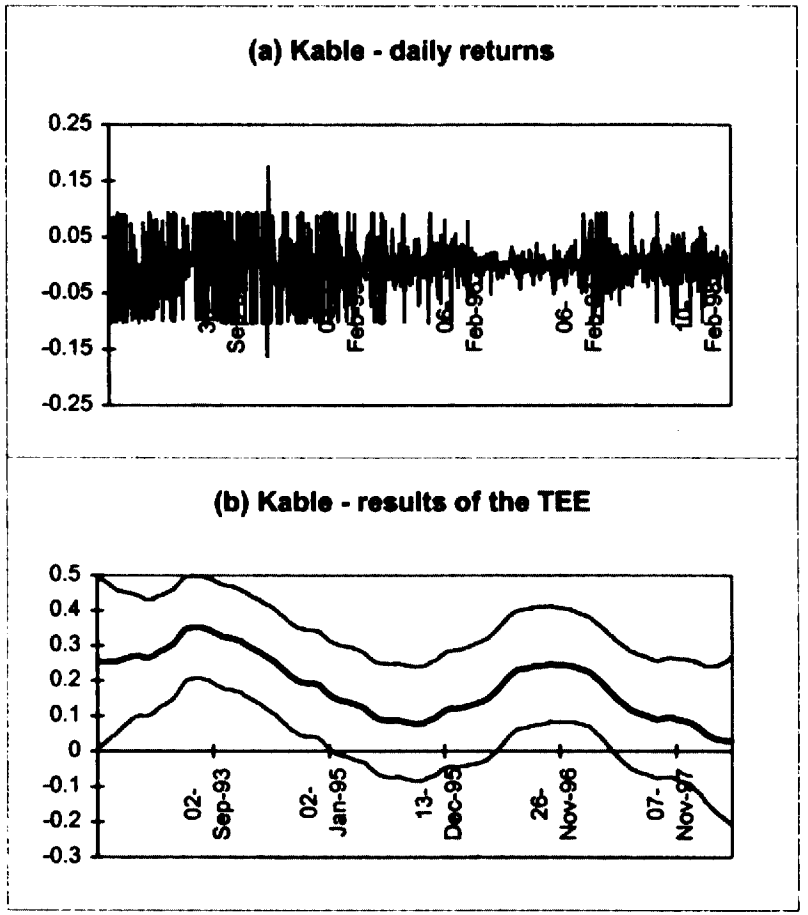


Figure 12. Daily returns and results of the TEE for the Kable's shares.

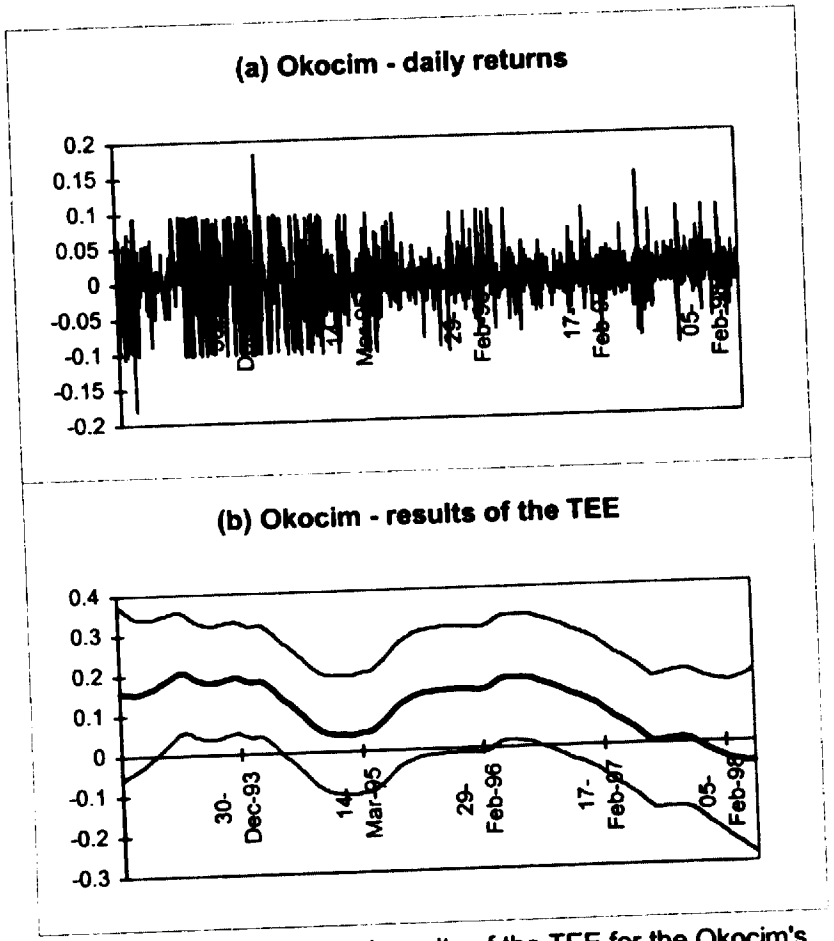


Figure 15. Daily returns and results of the TEE for the Okocim's shares.

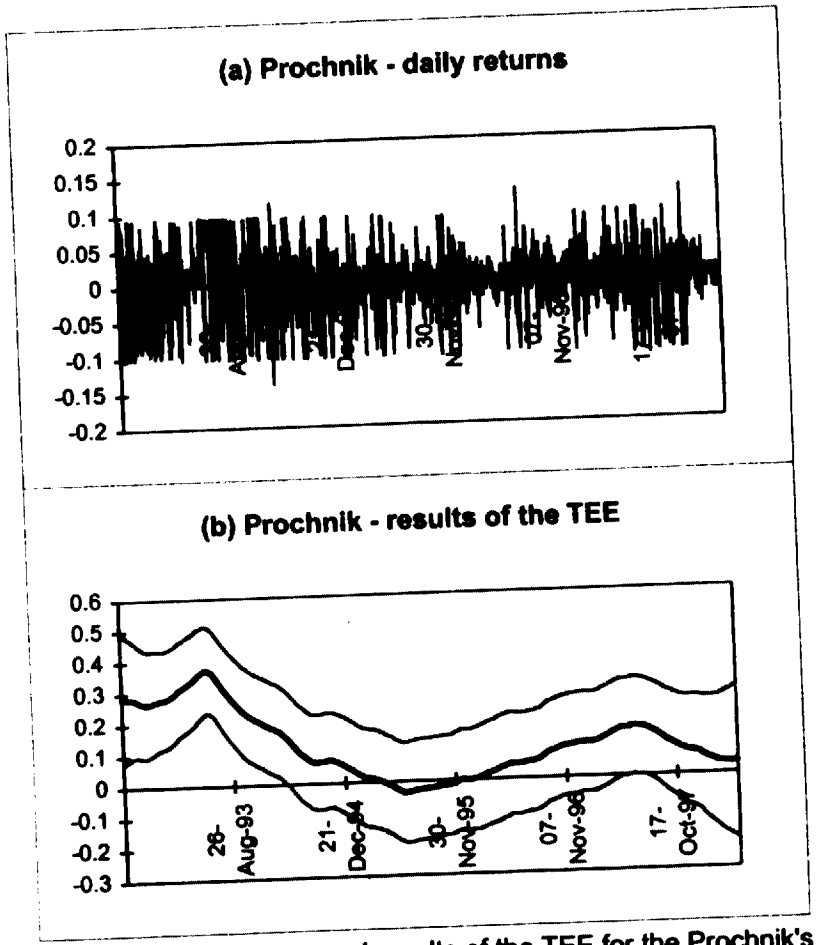


Figure 16. Daily returns and results of the TEE for the Prochnik's shares.

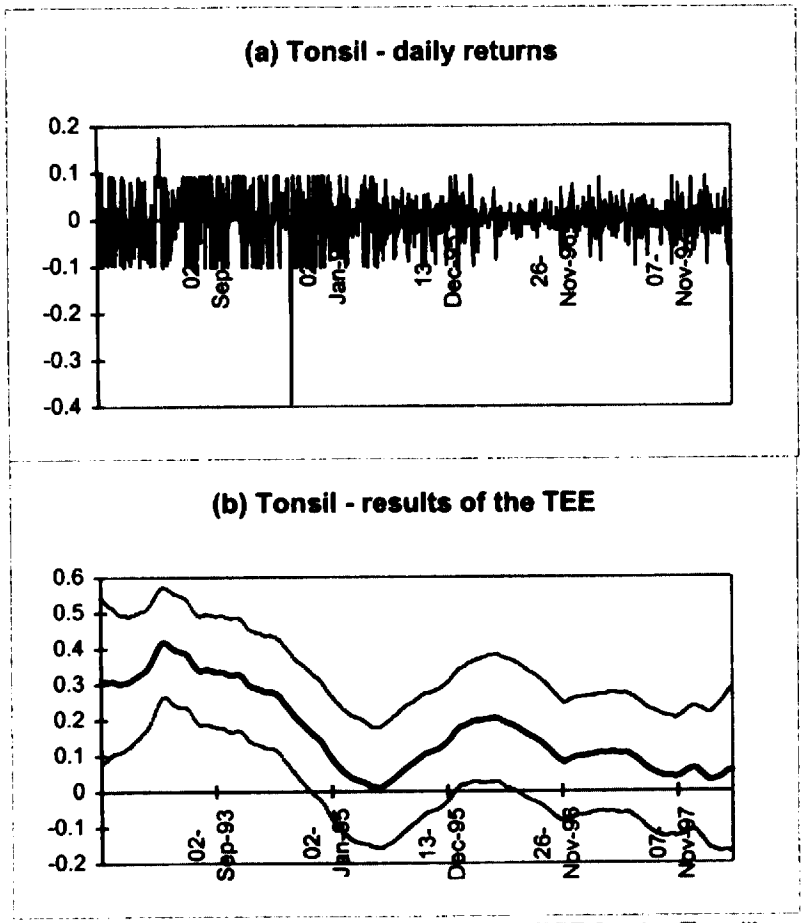


Figure 17. Daily returns and results of the TEE for the Tonsil's shares.

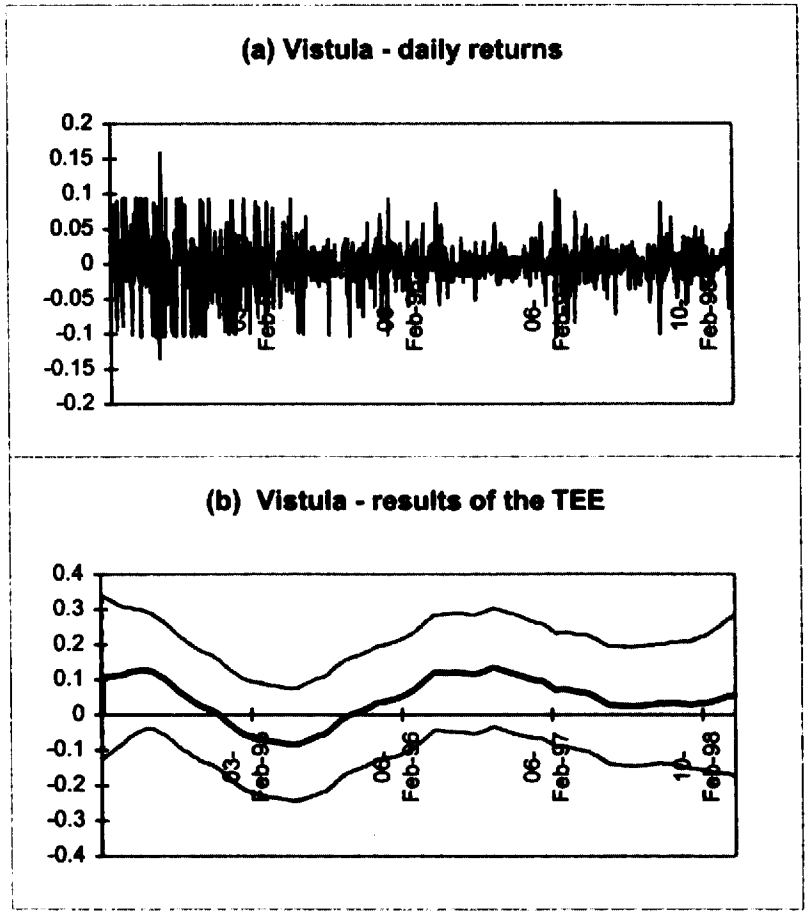


Figure 18. Daily returns and results of the TEE for the Vistula's shares.

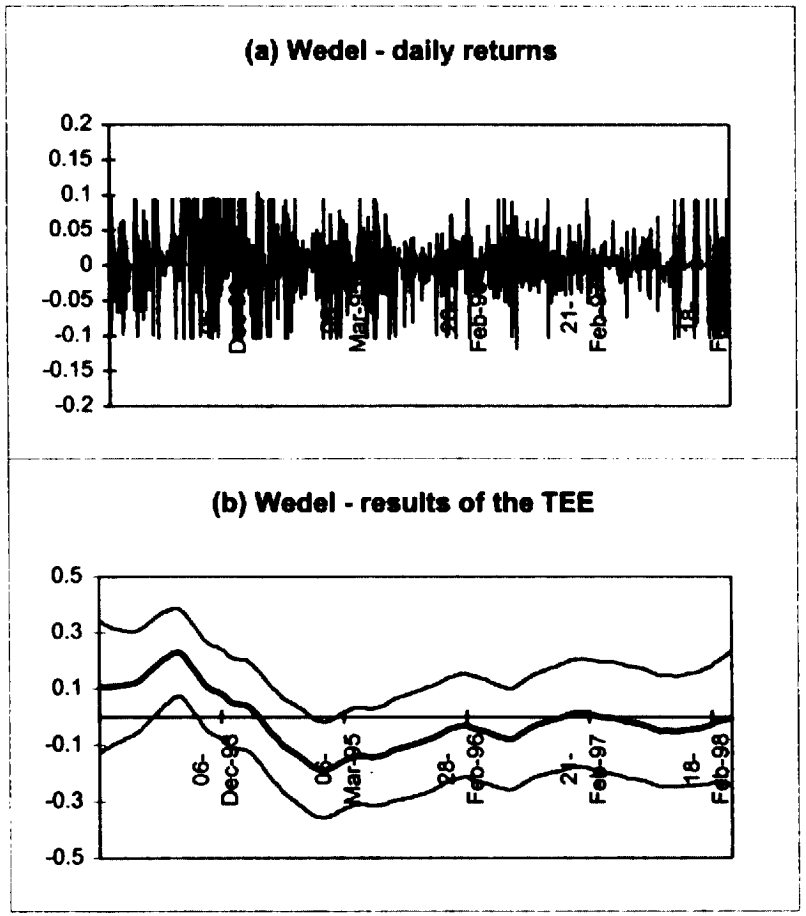


Figure 19. Daily results and results of the TEE for the Wedel's shares.

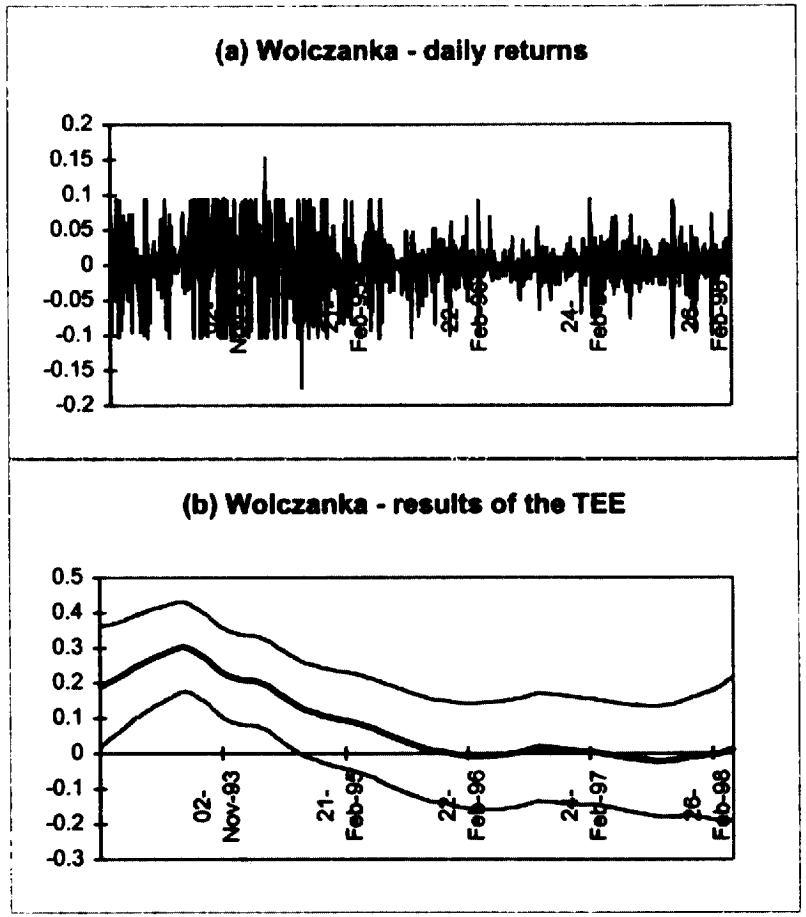


Figure 20. Daily returns and results of the TEE for the Wolczanka's shares.

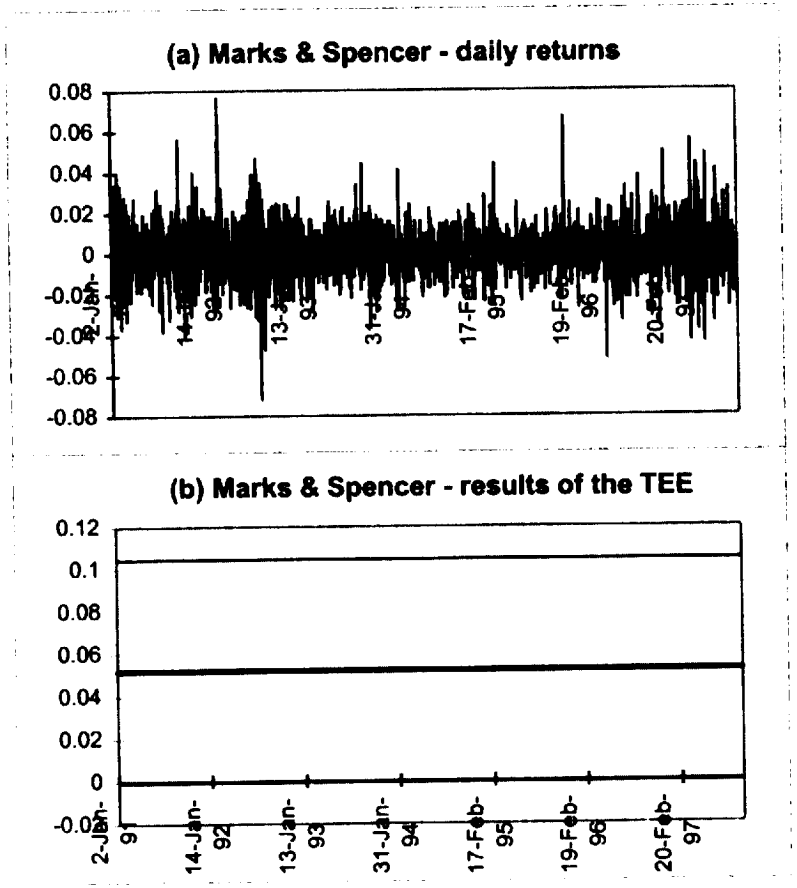


Figure 21. Daily returns and results of the TEE for the Marks and Spencer's shares.

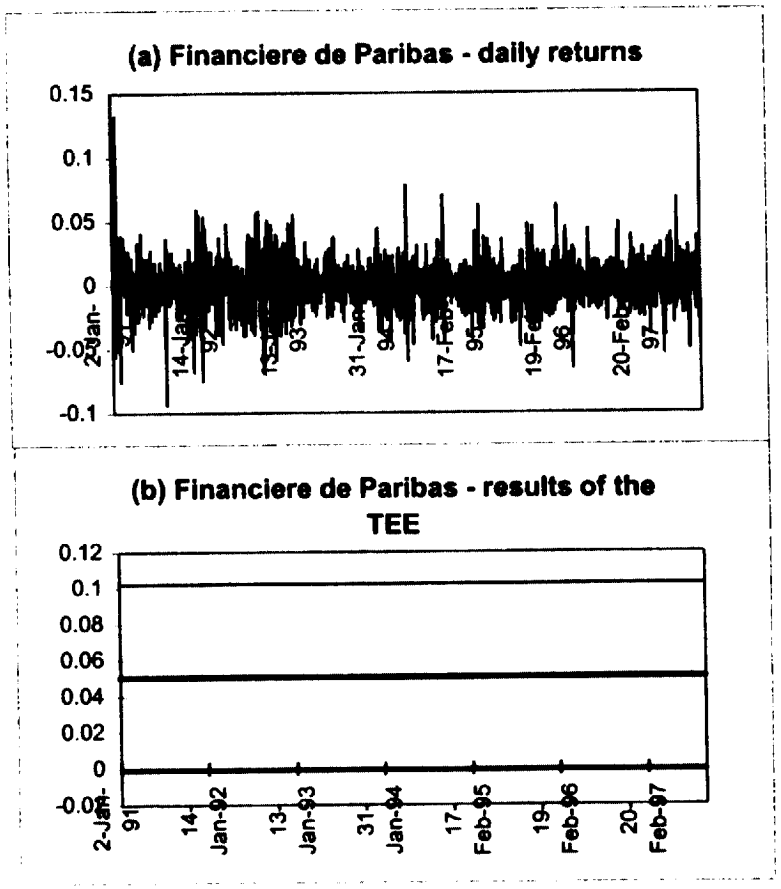


Figure 22. Daily returns and results of the TEE for the Financiere de Paribas' shares.

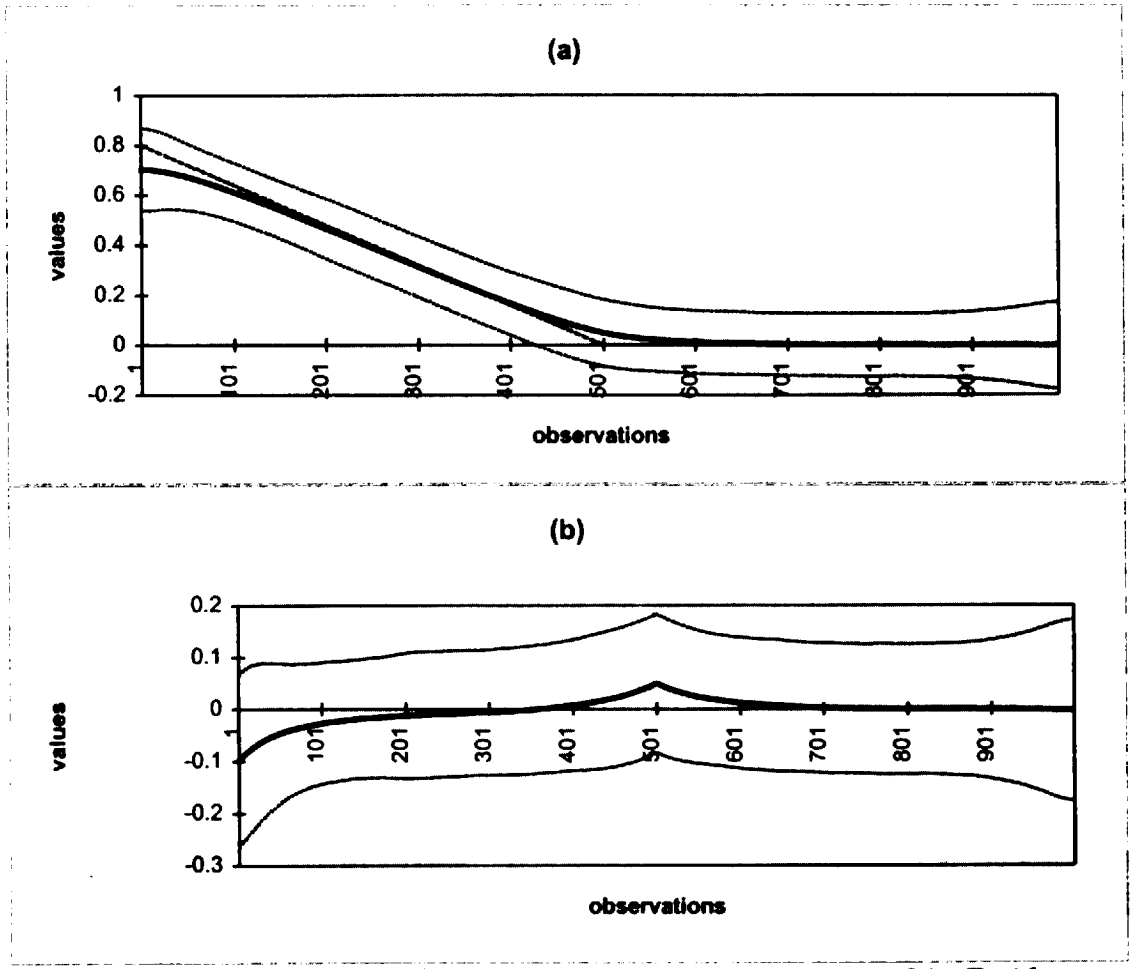


Figure A1. Results of the Monte Carlo simulations assessing the power of the Test for Evolving Efficiency. In part (a) the dashed line represents the assumed time path of the β coefficient, the solid black line represents the estimated time path and the dotted lines represent the 95% confidence intervals. In part (b) the black solid line corresponds to the difference between estimated and assumed values of the β coefficient. The dotted lines give the 95% confidence intervals.